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Gold mining and water quality conditions on public lands of the Yukon and Southwest Subregions of Alaska

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GOLD MINING AND WATER QUALITY CONDITIONS ON PUBLIC LANDS OF THE YUKON AND SOUTHWEST SUBREGIONS OF ALASKA

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Bureau of Land Management

I. INTRODUCTION

This report is the result of a field review of mining and water quality in Alaska. Gold mining, which employs hydraulic stripping or dredge boat operations, can have adverse effects upon fisheries and water quality. In particular, suspended solid concentrations, chemical oxygen demands, and turbidity are sometimes increased by mining to levels which can damage macro and microinvertebrate populations and greatly exceed maximum contaminant levels as recommended by the Environmental Protection Agency (EPA) or promulgated by the State of Alaska.

The primary purposes of this report are:

1. To characterize the setting in which gold mining is occuring in Alaska.

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2. Report observations at six mining locations or operations.
3. To analyze potential effects of selected mining methods on water quality under various physical conditions.
4. Perform a comparative analysis of natural variability in water quality as compared to potential changes due to mineral development.
5. Document authorities under which the Bureau of Land Management (BLM) should require surface management changes due to water quality constraints.
6. Recommend a water quality study and program direction for BLM in Alaska.

This review is constrained solely by the fact that existing data, quantitative observations, interviews, and the literature have been the information sources. No new technical water data were obtained. We recognize that comprehensive basic data are limited, but assert that sufficient information, data and personal observations are

available to set a course of action for the BLM in Alaska.

II. SETTING

Alaska is a vast state, with a land area of 586,400 square miles; five of the nine largest rivers of the United States; the lowest population density of any state (0.5 persons per square mile); and very limited transportation and communication networks. Because of its large size and the diversity of its physical features, Alaska has been divided into six subregions by the Interagency Technical Committee of Alaska (1970) (Figure 1). Three of these subregions, Yukon, Southwest, and South-Central, have been further subdivided on the basis of climate, physical boundaries, and population distribution. Mining operations visited during this review were limited to the Yukon, Northwest and Southwest subregions.

Most of Alaska's waters remain in their natural state, relatively unaffected by man, and are generally in compliance with water

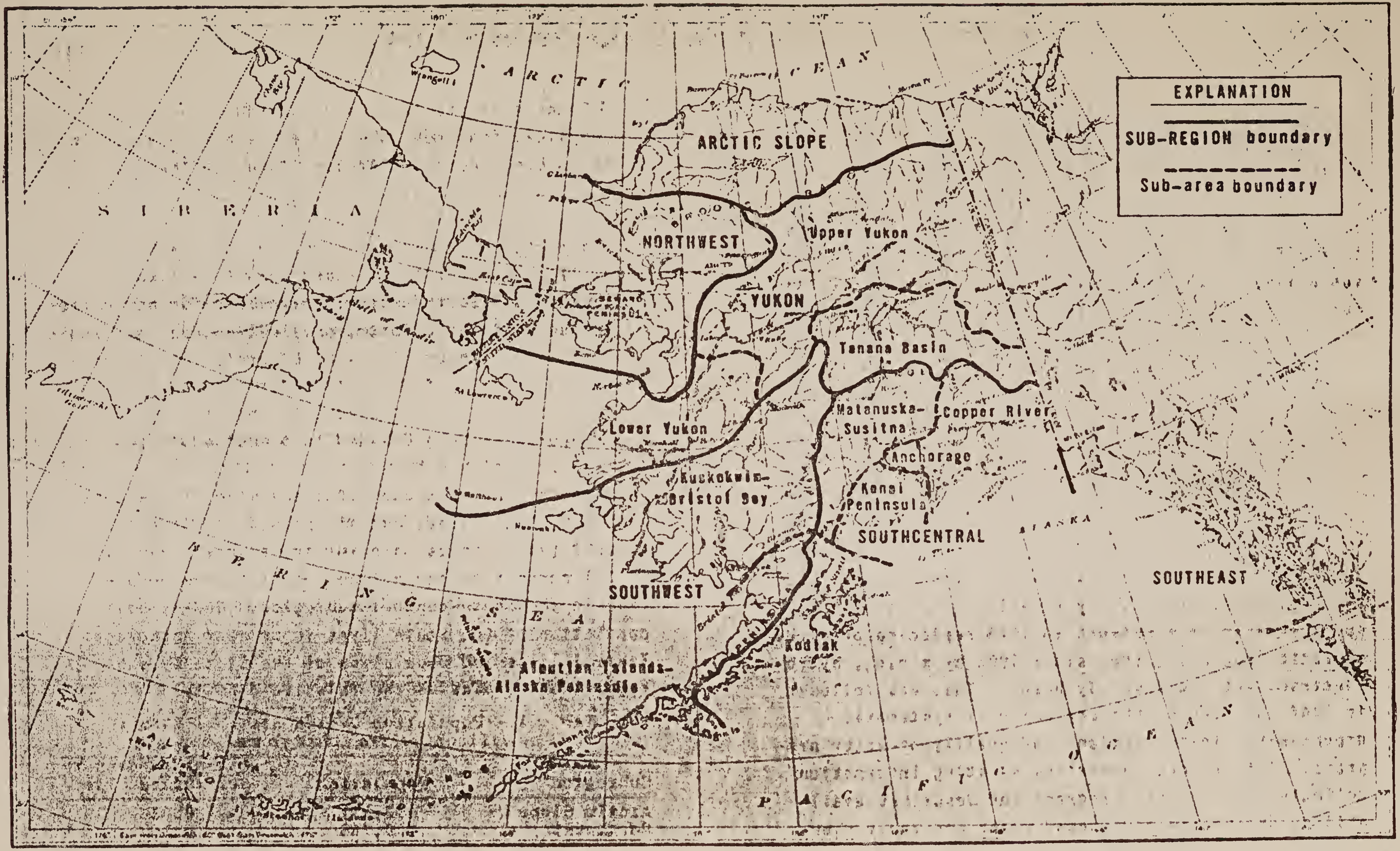

Figure 1.

Hydrologic Subregions
(Interagency Technical Committee of Alaska, 1970)

quality standards (Alaska Department of Environmental Conservation, 1977). However, normal chemical weathering and geochemical phenomena combine to produce some organic pollutants in surface waters of muskeg areas. Generally the water of streams, rivers and lakes is of excellent quality by any standard, with the exception of seasonally high natural suspended solids concentrations. Locally, some ground water supplies are highly mineralized, due to the dominant influence of the geologic environment on water chemistry.

Annual water production from Alaskan watersheds is immense, even neglecting the flow-through waters from Canada's British Columbia and the Yukon Territory. The 650 million acre-feet (a.f.) annual runoff production of Alaska nearly equals the 680 million a.f. produced by the 12 river basins of the great American West. The "last third" of the annual water production of this country is yielded from the five major eastern river basins (660 million a.f.).

Table 1

Alaska's Largest Rivers
(Norwood, 1968)

Name	Tributary to	Drainage Area Square Miles	Annual Runoff Acre-Feet	Annual Runoff Inches
Yukon	Bering Sea	330,000	157,000,000	9
Kuskokwim	Bering Sea	43,600	45,000,000	19
Copper	Gulf of Alaska	24,400	38,000,000	29
Colville	Arctic Ocean	24,000	9,000,000	7
Stikine	Pacific Ocean	19,700	45,000,000	43
Susitna	Pacific Ocean	19,400	31,000,000	30
Nushagak	Bering Sea	14,100	15,000,000	20
Noatak	Arctic Ocean	12,600	7,000,000	10
Kubuk	Arctic Ocean	12,000	9,000,000	14
Alsek	Pacific Ocean	9,400	15,000,000	28
Kvichak	Bering Sea	7,700	16,000,000	39
Taku	Pacific Ocean	6,700	8,000,000	22
TOTAL 12 largest rivers		523,700	395,000,000	
Remaining area drained by Alaska Streams		209,300	405,000,000	
TOTAL area drained by Alaska Streams		773,000	800,000,000	

Table 1 of Norwood (1968), represents receiving stream name, basin area, volumetric and runoff equivalent depth data for the twelve largest Alaskan rivers. This decrease in runoff depth with increasing drainage basin area is quite important in the consideration of mining effects on hydrologic conditions. Runoff for our purposes is considered to be that part of the annual precipitation leaving a land area as streamflow.

These data of Norwood (1968) and other data of the U.S. Geological Survey (USGS) (1976), show a weak trend towards decreasing water yield (inches depth) as basin area increases. Indications are that smaller watersheds (less than 30,000 square miles), often nearer the location of mining activity, have an average annual water yield of from ten to 25 inches. On the other hand, the larger river basins which receive the headwater stream impacts (say 50,000 to 300,000 square miles), generally have a yield of ten inches or less per year.

Because climate and geology are so diverse across this huge state, the seasonal and spatial variability in streamflow is wide. Yet to understand the water quality hydrology effects of mineral extraction, this variation must be dealt with because it is the streampower of streamflow which provides the energy required to transport settleable solids. In Alaska, it is a reasonable assumption that precipitation increases and evapotranspiration decreases with rising altitude.*

The Southwest subregion, which includes the Kuskokwin River, has a transitional climate, and rarely experiences violent storms.

The USGS has found that annual peak runoff usually occurs in summer with a secondary maximum flow in the fall. These peaks may result from snowmelt or rainfall events.

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* Recent work by Emmett (1972) confirms the orographic effect on precipitation of increasing altitude.

Recent work by Emmett (1972) has shown that over a range in size of drainage area of 100-100,000 square miles, there is little change in the values of unit runoff for the South-Central region; whereas over the same basin size range, there is a four-fold decrease in value of unit discharge in the Yukon River region. This probably indicates a relatively larger capability for watersheds of the South-Central region to transmit hydrologic effects of mining disturbances as compared to the Yukon River region.

Most of the mining effects in the Faribanks District are ultimately transmitted to the Yukon subregion (Interagency Technical Committee of Alaska, 1970) which is characterized by warmer summers and very cold winters. In this subregion, particularly the Upper Yukon area (including Chicken), the variability of streamflow is more nearly like that of the "lower 48" streams in the western states. April through October are the rainy months, with August being the wettest. Subregion streamflow and climatic variability in the

Northwest, South-Central and Southeast is unimportant for purposes of this report because so little mining activity was seen in those regions.

Alaskan streams and rivers are among the biggest sediment producers of North America. Much of this material originates at higher elevations as fragmentary material derived by mechanical weathering. Chemical weathering is a much more important force at lower altitudes, especially if moisture is abundant. Some additional fluvial sediment loading originates due to activities of man such as industry, mining, silvicultural operations, and road construction. The quantities and physical nature of all the above stream-borne sediments are influenced by topography, precipitation, temperature, geology, soils, and vegetation.

In Alaska, as in no other state, the characteristics and distribution of suspended sediments are made even more complex by the contribution

of glacial melt and sediments to many stream and river systems, particularly during the summer. In assessing the glacial streams of Alaska, which move the majority of its streamflow, Anderson (1970) has found that such streams have relatively low discharge variability seasonally due to the regulatory effect which ice storage places upon the headwater zones.

In the mining locations visited during the field phase of this water quality review, glaciers have little or no influence on the sediment characteristics of any of the receiving streams with the possible exceptions of the Mosquito Fork of the Fortymile, and the Iditarod. Headwaters of most mined watersheds visited do not extend to an elevation in which glaciers could subsist. It is in these clear water watersheds that the USGS has found suspended sediment concentrations during the summer to be generally less than 100 milligrams per liter.

The most important part of the environmental setting in Alaska for purposes of this study is the aquatic chemical environment, the least well understood of all components. We do know that the chemical water quality of all Alaskan streams, mined or undisturbed, is unique. Differences in specific conductance, pH, alkalinity, nutrients, and mineral composition are to be expected. This is due to the different mosaics of geologic formations within ground water aquifers and at the surface, drainage area differences, stream velocities, streambed composition, and channel geometries. Also a factor is that natural ground water discharge, and therefore its quality, may exert an overriding influence on one stream, or stream segment, but not another. This is the reason for increases in conductivity as winter approaches (U.S. Department of the Interior, 1969). An interim study (Woodward-Clyde, 1976) recently completed for the U.S. Fish and Wildlife Service, reveals that erosion of Alaska sub-artic topsoils can produce a wide array of water quality conditions in surface waters, including: anaerobic

decomposition in sediments; increases in color, iron, tannin, lignin, electric conductivity, total organic carbon and ammonia levels. In addition, such soil losses can significantly reduce pH of receiving waters.

Water quality goals for the state of Alaska are stated in the form of water quality standards. The Alaska Administrative Code, Title 18, Chapter 70, includes these standards, which were last revised in August of 1973; and approved by EPA pursuant to Sec. 303 of Public Law 92-500. These state-federal water quality standards for Alaska are summarized, in part, later (Appendix A). Each body of water in the state, including ground water, is classified for one or more beneficial uses. Then numerical or narrative criteria are assigned so as to protect water quality and provide for the stated beneficial uses. Numerical criteria include coliform organisms, dissolved oxygen, pH, turbidity, temperature, and color. Several narrative criteria also apply. A feature of Alaska's standards,

which provides even greater protection, is 18 AAC 70.050(b) which states, "The other fresh waters of the State are generally in their original and natural conditions and as such are considered suitable to serve all classifications established in the water use classification and criteria chapter (18 AAC 70.020)."

What this means is that all other waters of the state, until they are classified by the state to a lower use, must meet the most stringent standards of the Alaska water quality standards. This has resulted in the failure of many waters, completely unaffected by man's activities, to meet certain Alaska water quality criteria. This fact has been dealt with by making Alaskan standards only applicable to man-made alterations of state waters.

State of Alaska water quality standards are very important to the BLM's water quality compliance program in Alaska, as they establish the standards which the Bureau must apply on its lands.

Authorities of the BLM as regards water quality in Alaska may be found in Appendix B.

A final aspect of the Alaska environmental setting which bears on water quality effects of gold mining is the phenomenon of permafrost, another form of water storage (Figure 2). It affects, and is affected by site hydrology. Since it is virtually impermeable, it restricts recharge (deep percolation of overland or channel flow), slows ground water discharge and movement, creates artesian conditions, and limits storage capacity.

Permafrost, because of its inhibition of deep seepage, creates lakes and swamps (Anderson, 1970).

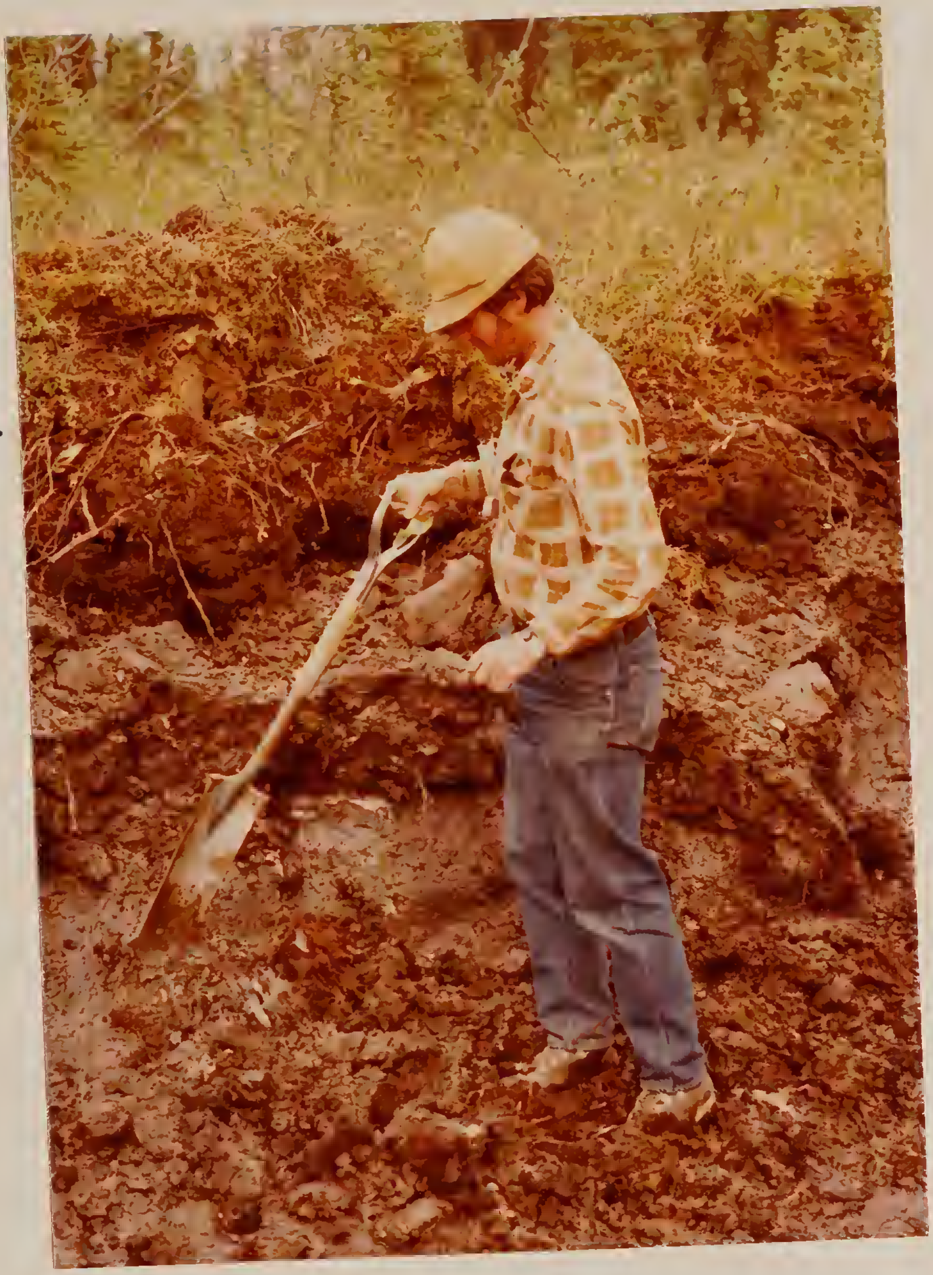

Figure 2.

Permafrost in a road-cut bank near Chicken, Alaska.

III. OBSERVATIONS AND INTERPRETATIONS

The approach used in this reconnaissance was simple. To be able to analyze the water quality problems associated with placer and dredge mining, one must see enough operations on the ground to appreciate the fact that each is unique with its own particular circumstances of water supply, topography, climate and placer deposits.

Due to so little data on water quality and hydrology of the small upland basins, it was considered impossible to select those physical and chemical quality parameters which may be major factors in ultimately explaining the water quality response to mining of small sub-artic watersheds. Therefore, a broad approach has been utilized with the thought that the collection and analysis of data will ultimately be initiated based on this study, and will be redirected and redefined as new information and understanding develops.

Figure 3 shows the general locations of some of the six mines visited. Those shown are: Livengood (a), Slate Creek (b), Happy Creek (c), and Nyac (d).

A. Livengood Sluice Operation

On July 12, 1977 this mine was visited, but viewing was done from a considerable distance. It is located on Livengood Creek, a tributary to the Tolovana River, about 54 airline miles north of Fairbanks (Figure 3). The setting is one of low hills, forested with black spruce, at about 600 feet above sea level. Overburden appears to be stripped by bulldozers after which the gravel is pushed by a bulldozer to a sluicebox at the creek bottom. Inflow to the operation is high in suspended solids (up to 12 percent by volume) due to hydraulic stripping operations three miles east at the Amy Mine (USDI, 1969).

Several years ago (USDI, 1969), personnel of the Alaska Water Laboratory measured turbidities during July, four miles below the Livengood Mine at 5,620 Jackson Turbidity Units (JTU). Suspended solids from operations on the Amy Mine to the east, and flow-through at the Livengood operation (the latter was

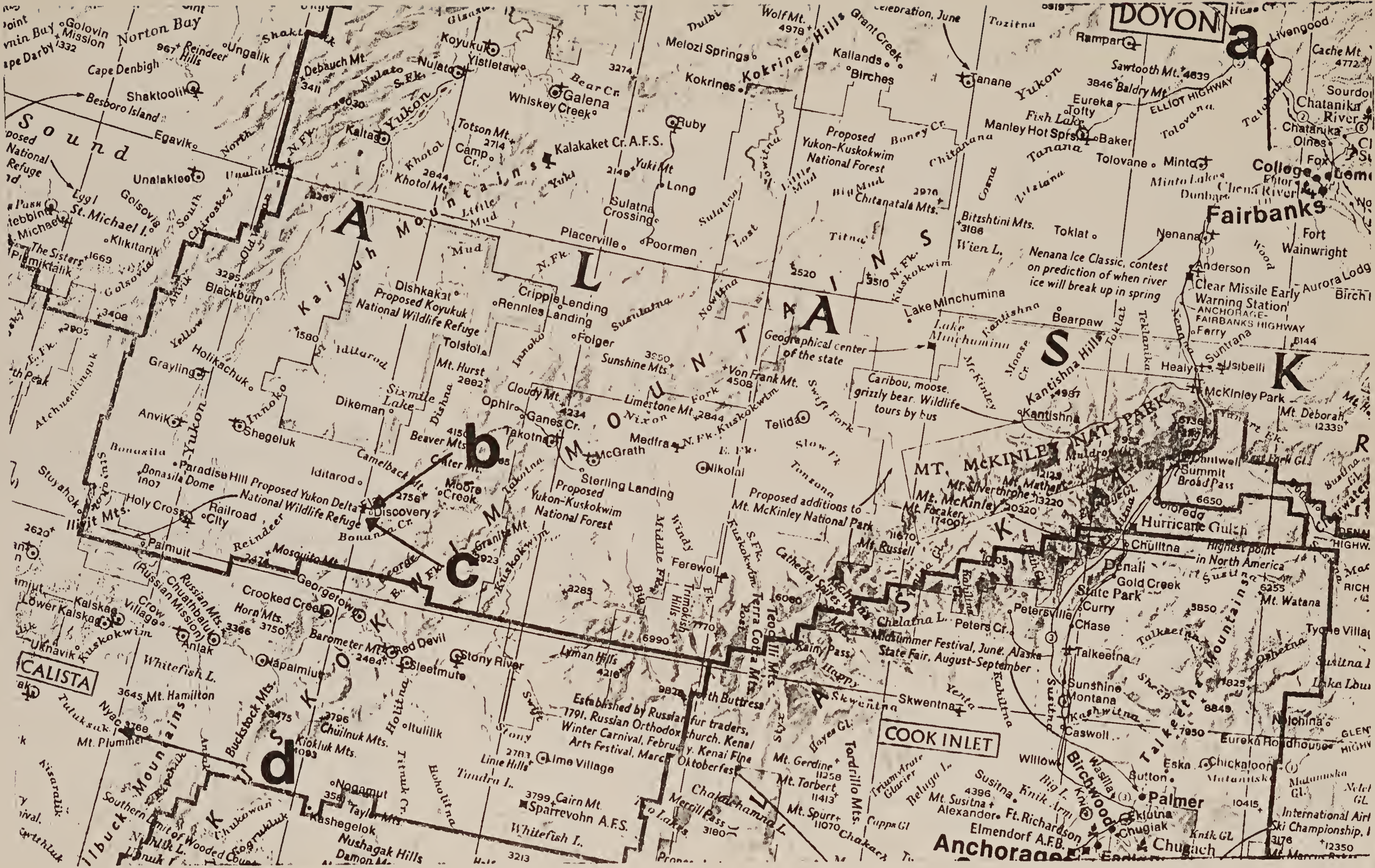

Figure 3.

Locations of selected placer mining operations.

temporarily out of operation) were sufficient to exceed State water quality criteria (5 JTU). It was concluded that the dominant cause in this instance was the Amy Mine.

Although we have no knowledge of any continuous streamflow or water quality record on any reach of Livengood Creek, there is an intermittent record of over six years on Hess Creek, 18.6 miles northwest of Livengood, on a minor direct tributary of the Yukon River. Although basin area of Hess Creek above Mastadon Creek (near the gaging station) is approximately 20 times the basin area of Livengood Creek above the Livengood Mine, a comparison is in order.

The Hess Creek data indicates a mid-May streamflow peak due to snowmelt, with no flow due to icing, December 21-April 30. The few water quality samples per year show dissolved iron exceeding EPA primary drinking water standards (July and

September, 1970 and July 11, 1975) and a similar excess of dissolved manganese above the same standard (USGS, 1976 and 1976). The spotty water quality data at Hess Creek for water year 1975 indicate no other problem with State of Alaska water quality standards or EPA standards and recommendations. It is not known whether any placer mining operations were active in the Hess Creek drainage above the gage during water year 1975; but according to the 1956 USGS 1:250,000 topographic map sheet "Livengood, Alaska", there were no such mines at this earlier date. Water year 1975 observations were made over a discharge range of 0.2 to 906 cubic feet per second (cfs). Turbidity never exceeded 9 JTU on any of the three sampling times, although color (platinum-cobalt units) levels exceeded State of Alaska legal criteria for untreated drinking water on most occasions. In general, the data from Hess Creek near Livengood show no effects of placer mining, based upon the very few sample values examined for 1975. The infrequent

high levels of iron and manganese were quite likely due to natural ground water geochemical contributions.

B. Chicken Creek (The Howard Bayless Mine)

We visited here on July 14, 1977. This is a dragline and sluicebox operation located in the immediate vicinity of Chicken, Alaska some 450 airline miles northeast of Anchorage, Alaska (Figure 4).

The Eagle, Alaska 1:2500,000 topographic map shows an elevation range of 1,800 to 3,775 feet above sea level for the approximately 20-square mile drainage area above the present-day operation.

Placer mining has been occurring in the Chicken area for 81 years, with most productive placers being discovered 1896-1905 (Mertie, 1938).

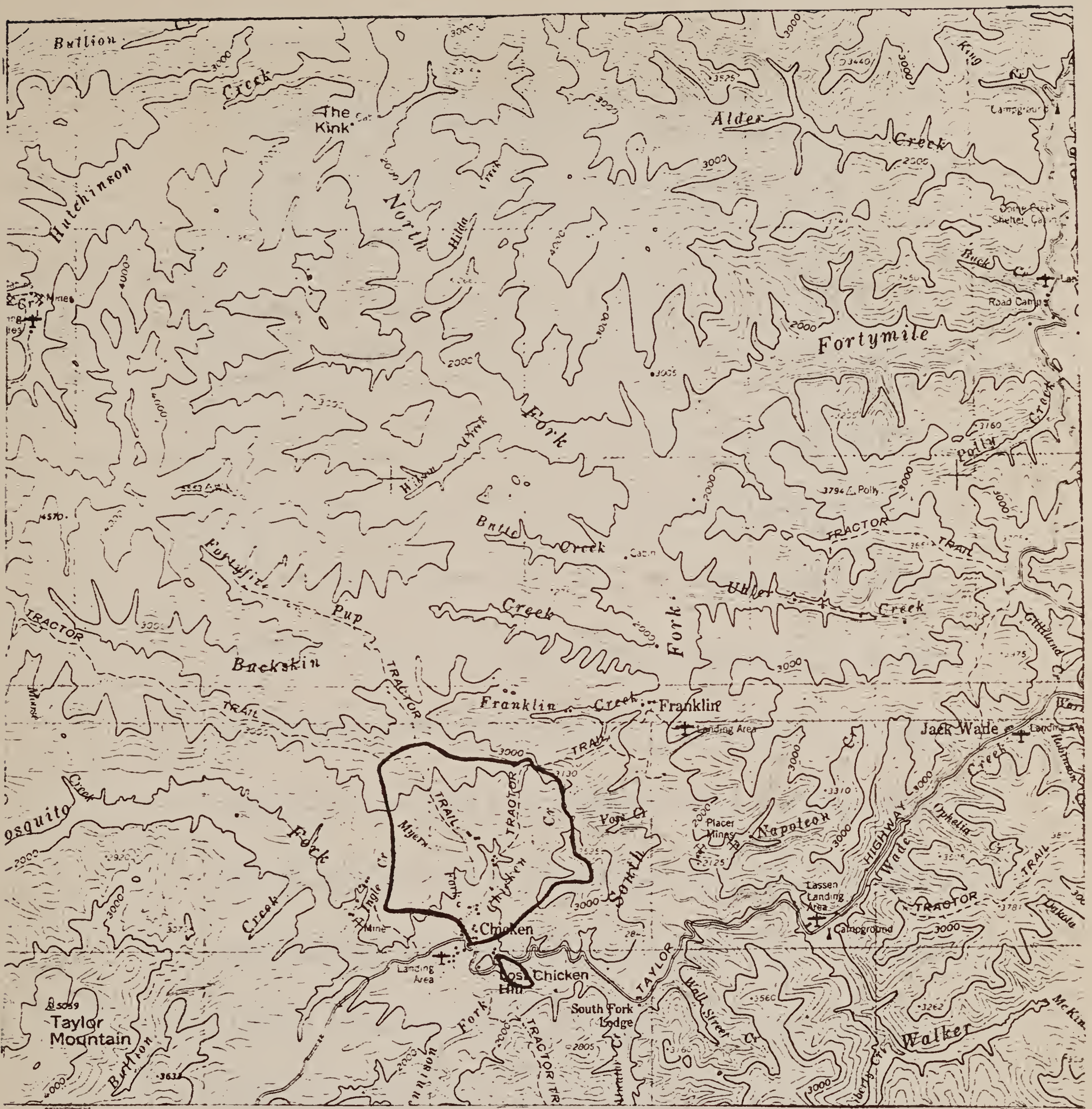

Figure 4.

Portion of the Eagle 1:250,000 topographic map, vicinity of Chicken, Alaska.

The mine is directly tributary to the Mosquito Fork of the Fortymile River, approximately 2 river miles above Chicken Creek's confluence with the Mosquito Fork of the Fortymile.

Terrain consists of broad ridges and rolling hills with fairly gentle slopes, white and black spruce trees, and copious undergrowth. Permafrost may be more continuous in this area than in the Livengood vicinity. The Chicken deposits were decribed by Mertie in 1938 as consisting of five to 15 feet of frozen alluvium with from negligible to 20 feet of muskeg overburden. The area of operation (Figure 5) is in the lower half of the watershed in a relatively flat stream channel and valley segment (less than 80 feet drop per mile). The worked alluvium is fairly effectively blocked from being washed down Chicken Creek by topographic breaks and pre-1968 dredge boat tailings.

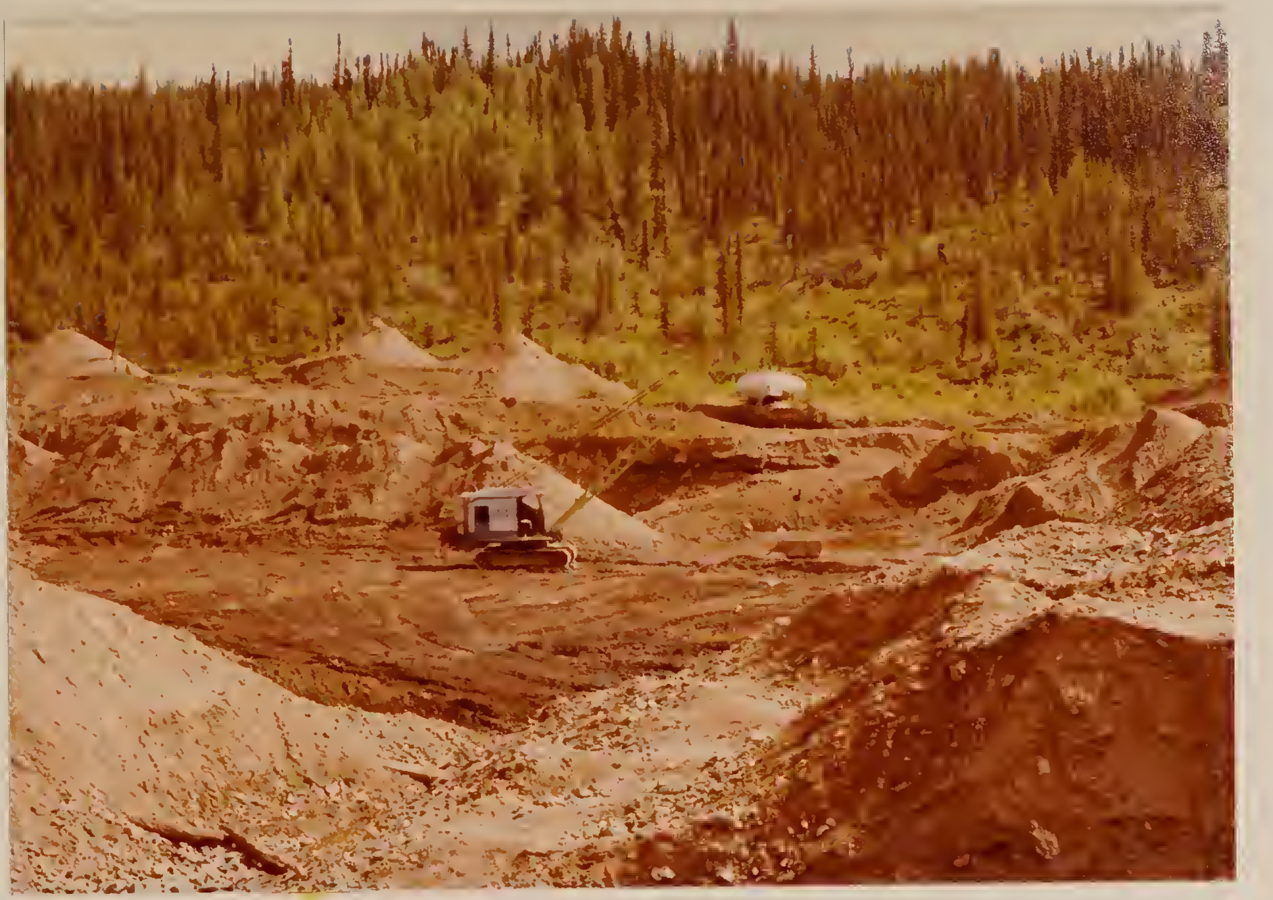

Figure 5.

The present operation consists of a 1.5 cubic yard (cy) dragline, sluicebox, washing operation, and a pumping recirculation system capable of moving the 180,000 gallon per day water requirement.

Historically, lack of an adequate supply of water from the Myers Fork tributary of Chicken Creek has made larger scale

hydraulic and dredge boat operations marginal. Mr. Robert Dittmore, present co-operator, stated that a circulating 250,000 gallon per day water requirement was needed for the old 20-man dredge boat operation. This operation has been shut down since 1968 due to labor costs and decreasing baseflow in Myers Fork. As early as 1912, Ellsworth and Davenport recognized factors at Chicken Creek which contributed to a relatively low water yielding efficiency from this comparatively small drainage area. Thus, the technical feasibility of mining operations at Chicken, from a water supply standpoint at least, is highly dependent upon weather conditions, which have been on the arid side since 1975.

The operation was not functioning the day we visited due to a parts delay, so sluicebox discharge was not assessed.

This particular operator was quite familiar with the Federal

Water Pollution Control Act Amendments of 1972 (P.L. 92-500) and the state requirements, having served in the Alaska Legislature for eight years and working as an assistant to a former Governor of Alaska. He was most concerned with the uncertainty of just how clean an operation the various water quality laws would require of him. The decision to invest in a corrective system could be a costly fatal one from the industry standpoint should the government strengthen requirements just a few months later. The inherent charge of bureaucratic indecision, over exactly what water quality standards will apply to the miners, surfaced during many of our discussions with other operators as well.

It is claimed by operators at the Chicken Mine, and generally by many Alaskan gold miners, that the quantities of turbid water issuing from the sluicebox and eventually reaching the stream channel are insignificant in comparison with the

natural valumes of turbid water produced every year by snowmelt and rainstorm runoff. Logical as this claim may sound, unfortunately there is absolutely no streamflow and sediment data record anywhere in the vicinity which can be used to prove or disprove the assertion. Not only is there no baseline data on Chicken Creek, the Mosquito Fork, to which it is tributary, is also ungaged; as is the receiving river of the Mosquito Fork, the South Fork of the Fortymile River. Therefore the first theoretical reference point in the eastern Alaska drainage network, at which the above industry claim could be assessed in relation to the impacts of the Chicken Mine, is on the Yukon River at Eagle, a distance of about 35 miles below the confluence of the Fortymile with the Yukon. This would be approximately one hundred river miles downstream from Chicken. At Eagle, the proportion of the Yukon River discharge attributable to the 20 square mile Chicken Creek drainage would be insignificant as a percentage.

Clearly, assessment of the water quality standards compliance (EPA and Alaska Department of Environmental Conservation) for Chicken Creek downstream in the Fortymile or Yukon Rivers is illogical, since naturally occurring high suspended solids loads in rivers of those size cause turbidity and occasionally other violations of State water quality standards every year. An additional confounding fact is that the cumulative, diluted effect of a number of mines is the most one could hope to sort out at this location on the Yukon. The only location where successful field monitoring of the Chicken Mine could be accomplished is up on the lower reaches of Chicken Creek. To the miners, that is unfair.

Although State of Alaska turbidity and color standards have been periodically exceeded at the Chicken Mine, it is concluded that the off-site impact downstream on the Yukon River is probably academic, particularly in view of natural turbidity

levels which sometimes exceed State standards. The consequences of these periodic violations on the values of Chicken Creek biota and riparian habitat are unknown.

The rather small streamflow yield of this basin lessens the likelihood that serious damage is being done by the present placer mining activities in the Chicken Creek drainage.

C. The Lost Chicken Mine

In his review of gold placers of the Fortymile, Eagle and Circle Districts (1938), Mertie discussed the Lost Chicken operations as they appeared in the summer of 1936, and their history. Hydraulic stripping of heavily vegetated overburden was conducted at this location as early as 1936.

Lost Chicken Creek, a small short drainage, flows southward in an asymmetric valley to the South Fork of the Fortymile

(Figure 4). Its entrance to the South Fork is approximately one-half mile below the confluence of the Mosquito and Dennison Forks (which together become the South Fork of the Fortymile). Sideslopes in the Lost Chicken watershed are steep, particularly east of the creek. It is a sluicebox operation employing three men; however, washing was not occurring the day of our site visit.

Our review of operations at this mine took place on a rainy July 14, 1977. It is impressive how little manuevering room is available in the valley bottom, which, due to the development of man-activated alluvial fans and terraces, is barely 50 yards wide at the most (Figure 6).

Massive permafrost deposits are present on the sideslopes, particularly the steeper east side. Years and years of hydraulic stripping, utilizing ditched water from the stream

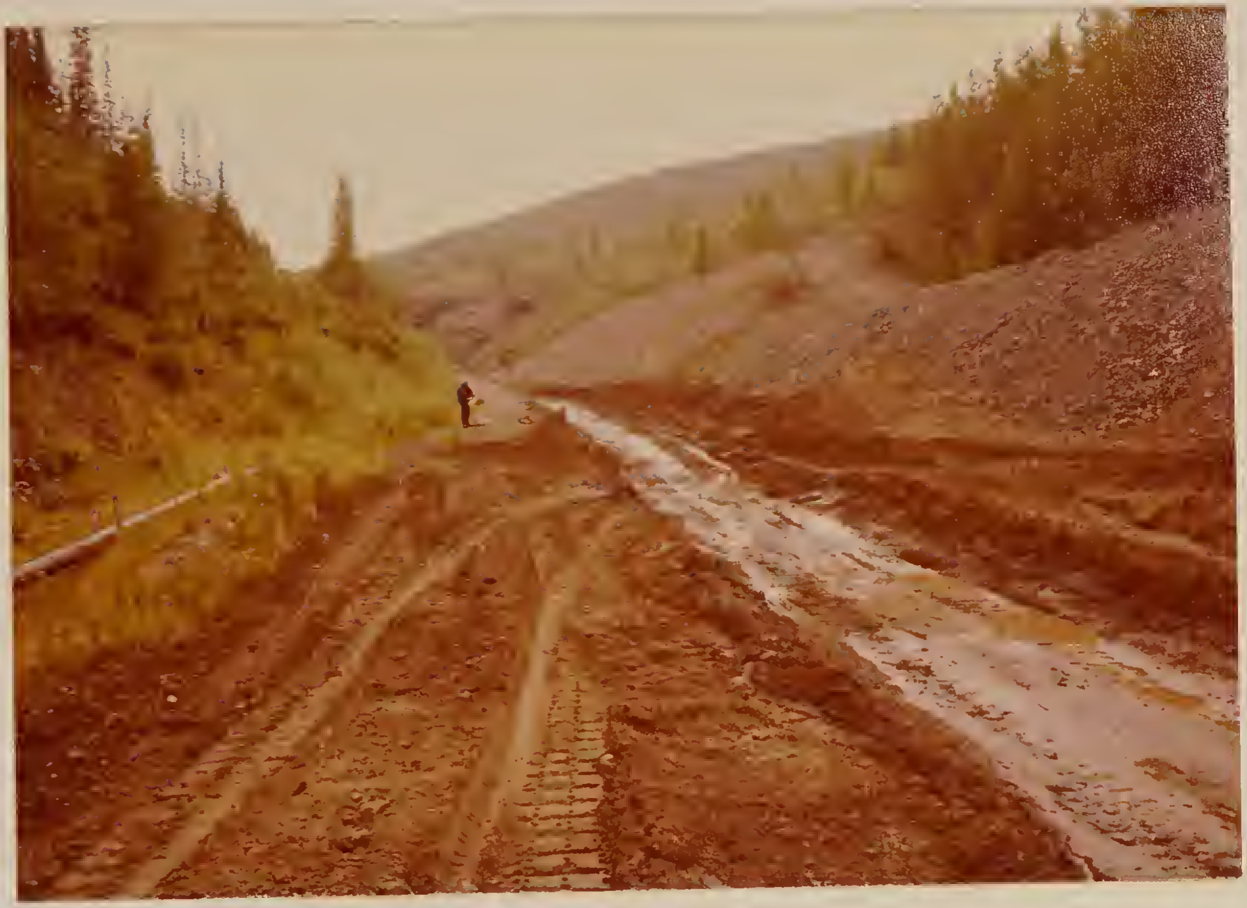

Figure 6.

head, have created huge cutbanks in the ice-rich permafrost which retrogressively melt as they absorb solar radiation and slough off into the stream, thus continuing the erosion process via thermal degradation. Although this small basin does not carry a large stream, the relatively high water content of the ice, together with the high volume occupied by ice, have combined to create very muddy, inconvenient

conditions through the sluicing and gravel storage portions of the valley bottom. Coupled with the silts and clays held by the ice and the highly organic peat-like overburden, these factors, when superimposed over natural rainfall events and the forces of the hydraulic giant water cannon, have combined to create tremendous silt transport from Lost Chicken basin. These conditions have certainly not developed in just a few year's time. Deep solution cavities, channels, and permafrost spires, reminiscent of Utah sedimentary goosenecks and chimneys, are widespread in the more severe pockets of thermal erosion. A strong damp organic odor is quite noticeable as one walks down parallel to the stream course. Gullies as much as six feet deep with waterfalls have formed in the channel area.

To mitigate the siltation effects of the hydraulically stripped overburden on the South Fork, the mining operator, Mr. Hanks, constructed earlier this summer, a series of

approximately ten dikes along the north bank of the South Fork, at an acute angle to the direction of flow.

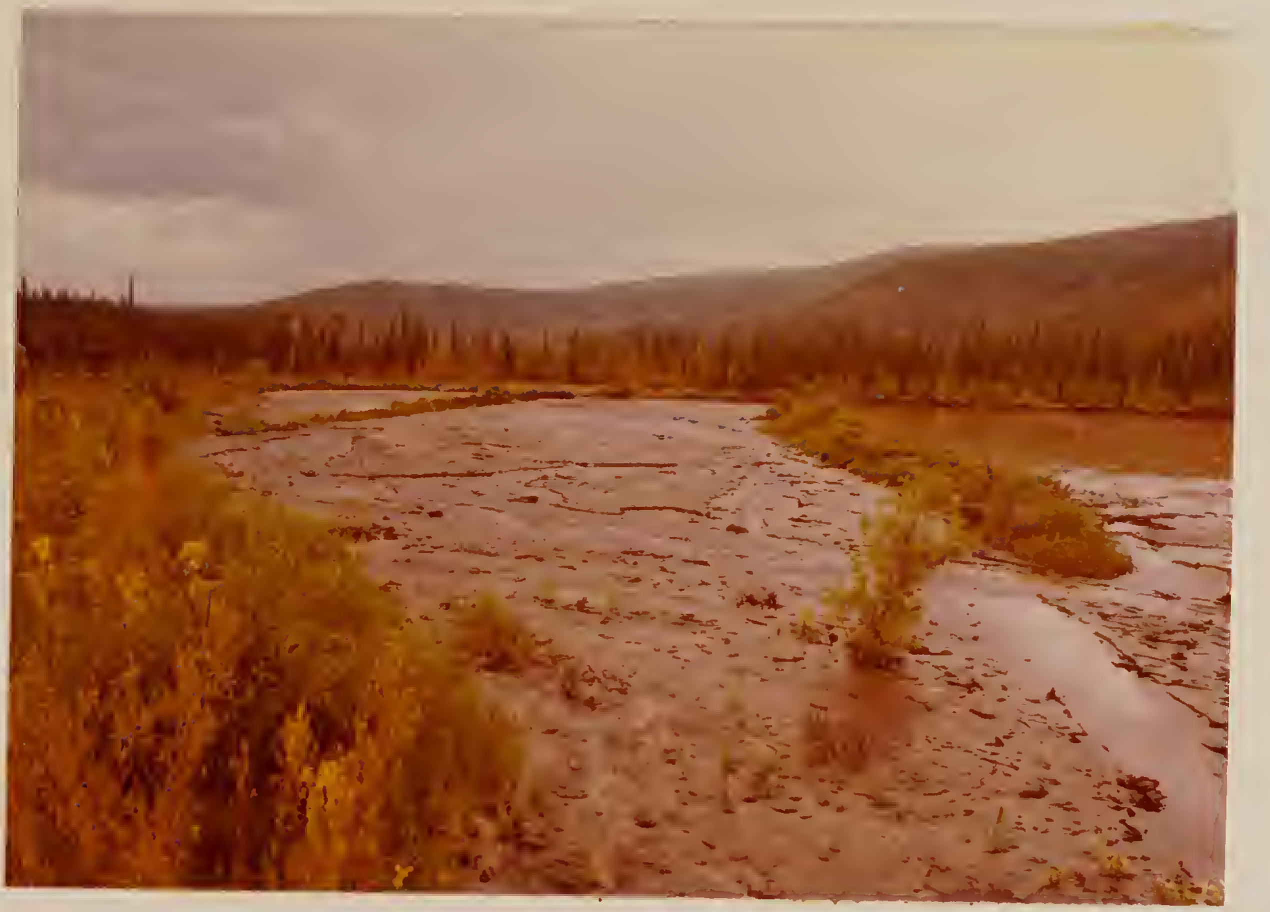

Figure 7.

Figure 7 shows three dikes and the river's course from right to left, in the background.

These structures detain the silt-laden stripping effluent, reduce water velocities, and allow for a large increase in suspended load settling time. As they fill, overflow occurs around the left (upper) end of each dike, and thus inflow

progressively moves down across the floodplain through the dike system. Sediment deposition in the settling ponds is from two to 12 inches depth. The willows, Achillea, small bushes, and other low-growing plants appeared to have effectively trapped suspended solids. However, it is impossible to know, given the absence of any samples, exactly how large a proportion of the sediment (which in past years, travelled directly to the river) is now detained by the dikes. The Woodward-Clyde (1976) study found that in most cases, settling ponds were an effective device for improving gravel operation washwater quality (settleable solids and turbidity). The same study found such ponds "somewhat effective in reducing oxygen-demanding matter and nutrients if controlled algal growth is allowed to form in the pond." Whatever effectiveness we might speculate on the part of these settling ponds, they will fill in a few years and without maintenance, will become much less effective.

Local people made the observation to us that the South Fork was quite muddy even during the past summer when the Lost Chicken effluent was being filtered through this network of dikes. Substantial fines were observed in gravel interstices at the river. Undoubtedly most of that material had already been scoured out by high spring flows on the South Fork. Several dikes were breached by the Spring 1977 high flows, causing some headcutting back up stream in the pond alluvium.

The relative importance of the quantities of suspended solids, contributed to a river like this from man-made effects as compared to natural high flow phenomena, is a major unknown and will continue to be so in the absence of good field measurements. Ice action as a mechanical force in the Fortymile River system is known to be responsible for significant bank cutting. Mr. and Mrs. Bob McComb of South Fork Lodge and long-time residents of the Chicken area,

according to Lotspeich et al. (1970), stated that the turbidity of the Fortymile River, following the "Y34" fire was worse at times than any they had seen during the days of active placer mining in the Fortymile mining district. At that time they were unable to use the water for domestic purposes. Deposition of sediment into the gravel stream bottoms from these stripping operations has much the same physical effects as sedimentation caused from gravel removal operations (Woodward-Clyde Consultants, 1976). These include decreasing the porous media flow through the substrate and decreasing channel recharge rates to ground water bodies.

Mining operations at this mine are more potentially damaging than most visited during this field trip, due to the large amount of overburden being stripped, presence of permafrost, highly soil organic content, and the less than one mile downstream distance to a fishery. The Bureau of Land

Management, and the federal government in general, would probably accomplish very little by attempting a shutdown of this operation. Monitoring the water quality effects of such a dike system is essential for providing the operator feedback on the effectiveness of the mitigation system of settling ponds. The long-term effect of operations at the Lost Chicken Mine is that even long after mining operations cease, the sediment yield from that small basin will be significantly greater given the large amount of disturbed soil in the area.

D. Slate Creek Mine

Moving from east-central to west-central Alaska, brings attention to the Iditarod Mining District. Located approximately 380 miles southwest of Fairbanks, it is drained on the north side by the Yukon and on the south by the Kuskokwim River. Both operations visited in this district are within the Iditarod sub-basin of the Yukon. The first

operation viewed (July 17-18, 1977), was the Otter Creek Dredging Company, owned by John A. Miscovich operating on Slate Creek. Slate Creek is a major tributary stream which enters Otter Creek from the south, in a setting of spruce-covered hills and valley floor muskeg. Figure 8 shows the Slate Creek operation, looking toward the west down Otter Creek towards Flat. The Flat Creek Placer operation presently operating on Happy Creek, will be discussed in the next section (E). A topographic inset from the 1956 1:250,000 Iditarod quadrangle is shown in Figure 9.

The relative drainage area sizes of the streams affected by this mine are: Slate Creek (20 square miles); Otter Creek (200 square miles); the Iditarod sub-basin (unknown area); the Innoko sub-basin (unknown area); and the Yukon River basin (over 500,000 square miles).

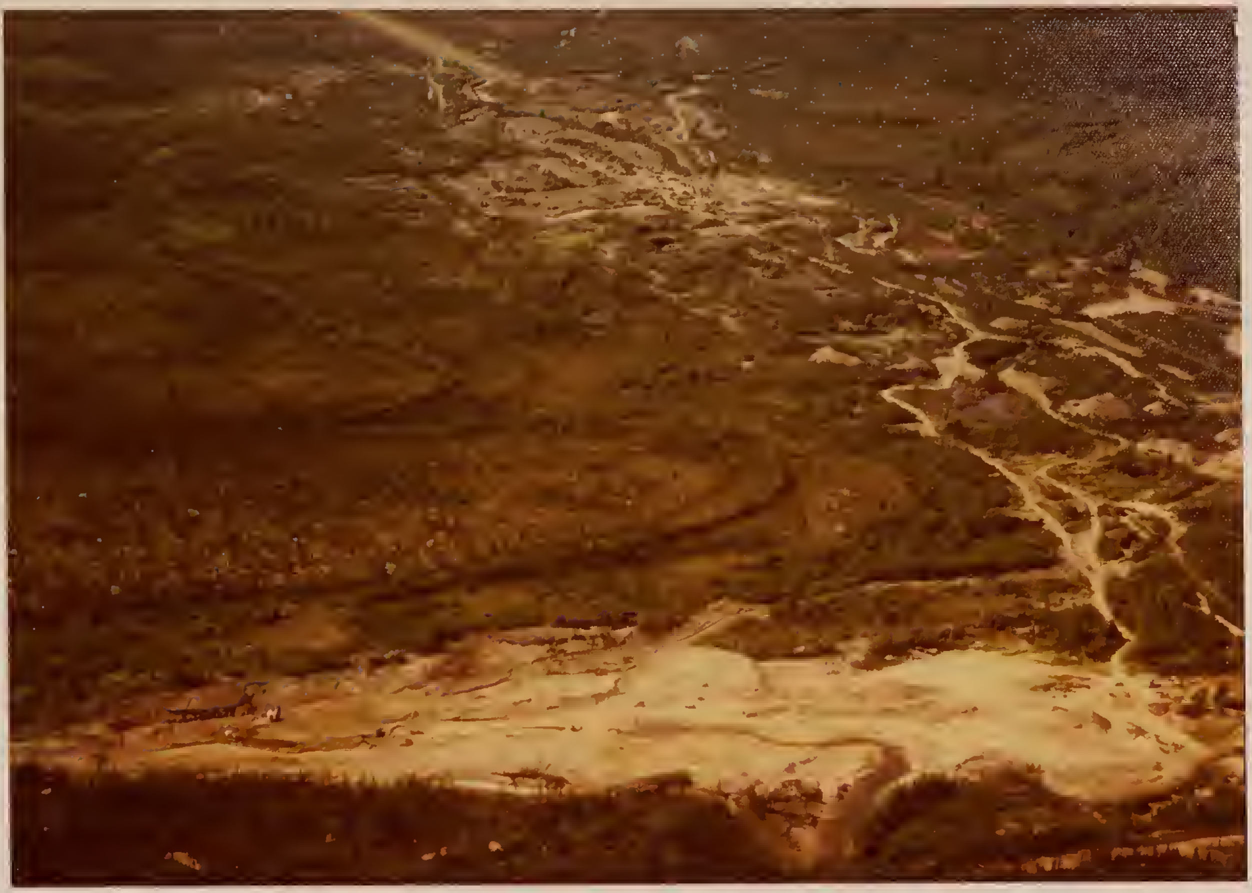

Figure 8.

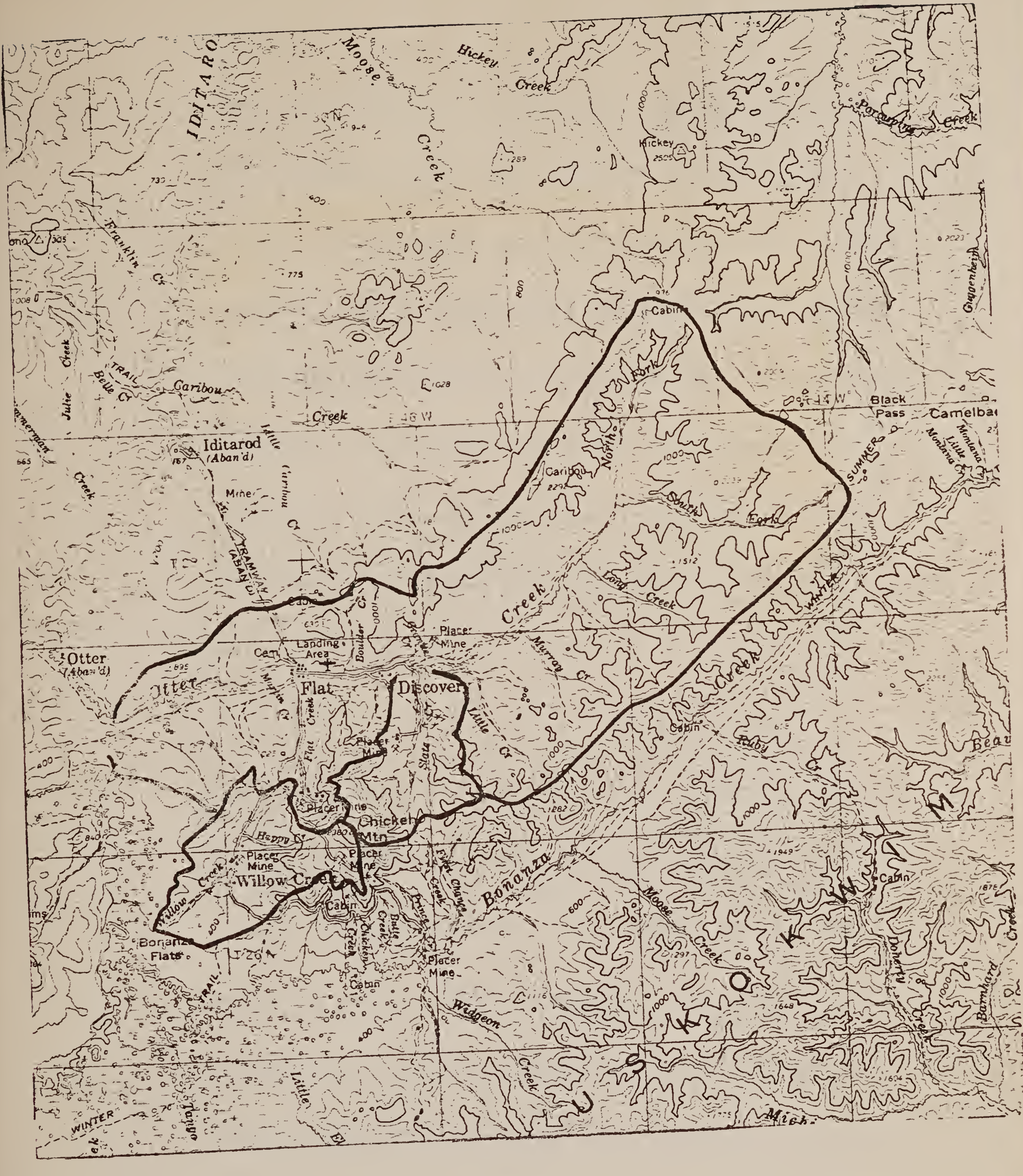

Figure 9.

Portion of the Iditarod 1:250,000 topographic map, vicinity of Flat, Alaska.

Gold was discovered in 1908 at Otter Creek by W. A. Dikeman and J. Beaton (Eakin, 1914). Three and one-half million dollars in total gold production was yielded by the Iditarod District in 1912. Dredge boats were active in the District until 1966, particularly in the area of Flat. Their evidence is visible in a previous figure (Figure 8). The stream receiving all direct impacts of mining on Slate Creek is Otter Creek, which contains rainbow trout and grayling, but no salmon fishery.

The mining method on Slate Creek is typical of many hydraulic mining operations in Alaska. A water diversion system, D-8 tractor, Stang 6-inch Model DDH intelligent monitor, and sluicebox are all critical components. The automatic double direct drive monitor, an invention of Miscovich (Figure 10), delivers 800 gallons per minute with a pressure of 35 pounds psi at nozzle-tip. The average daily volume of gravel

washed is 500 cubic yards (Figure 11). The force of the hydraulic water jet puts all but the largest materials into motion through the sluicebox (Figure 12). Gravel is supplied to the sluicebox by means of the bulldozer, and tailings are dispersed from the outfall by the same method.

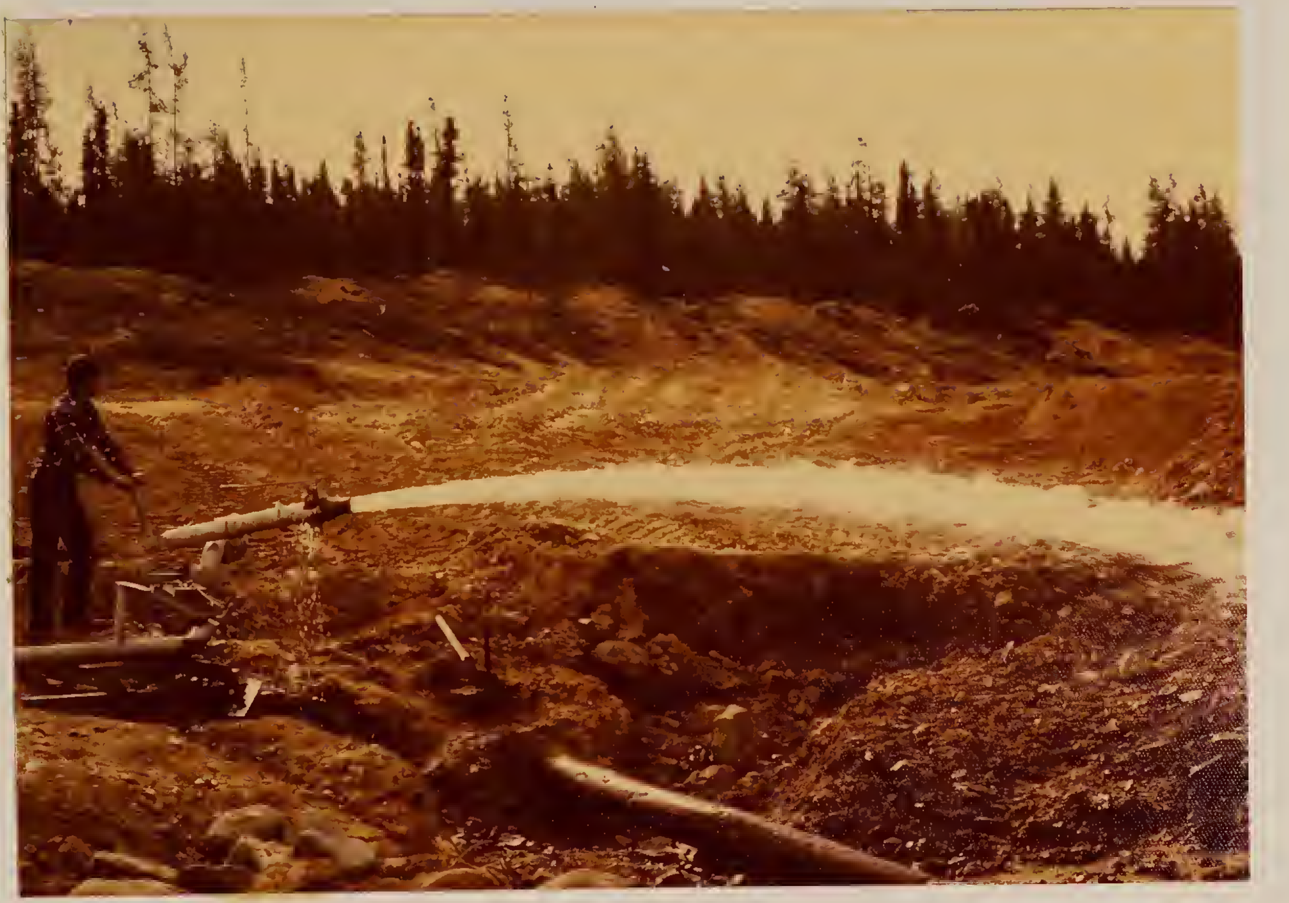

Figure 10.

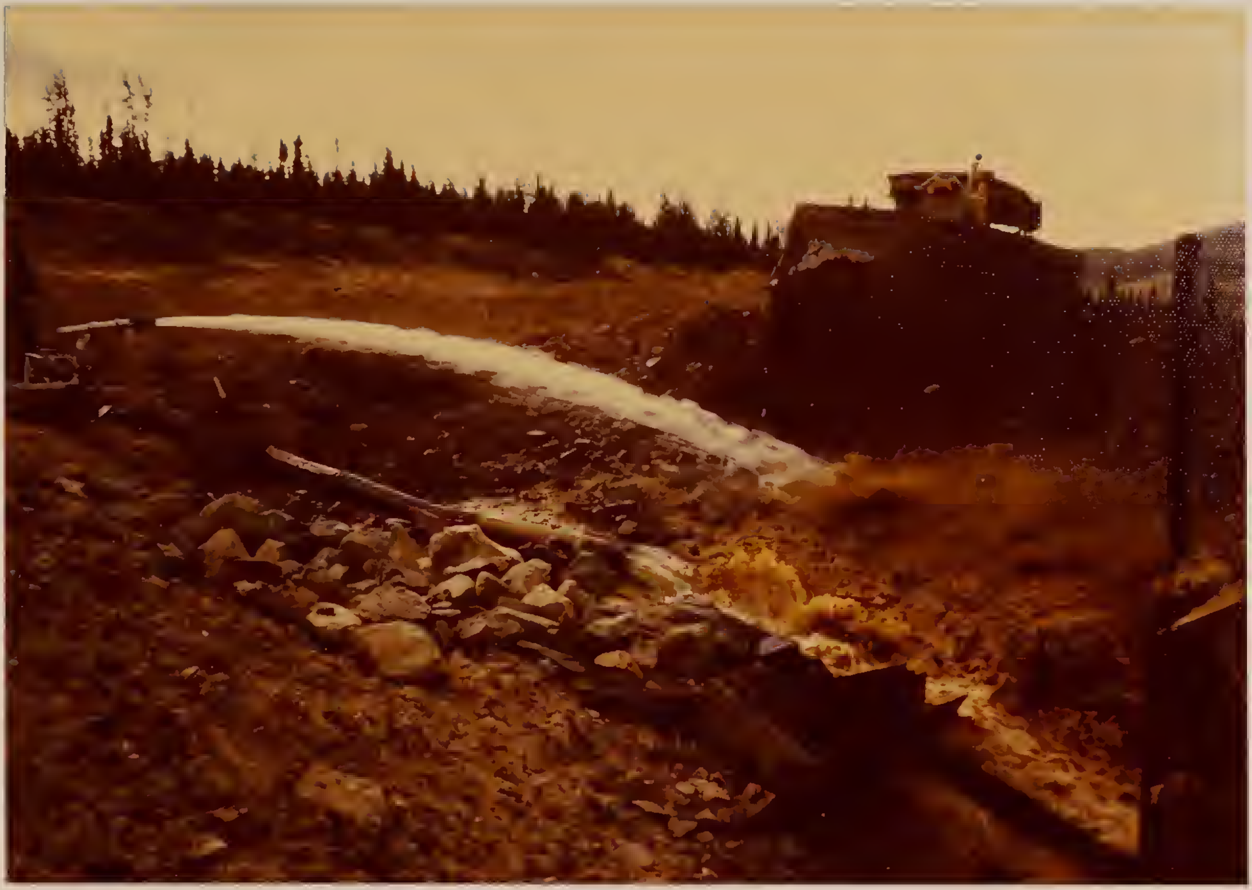

Figure 11.

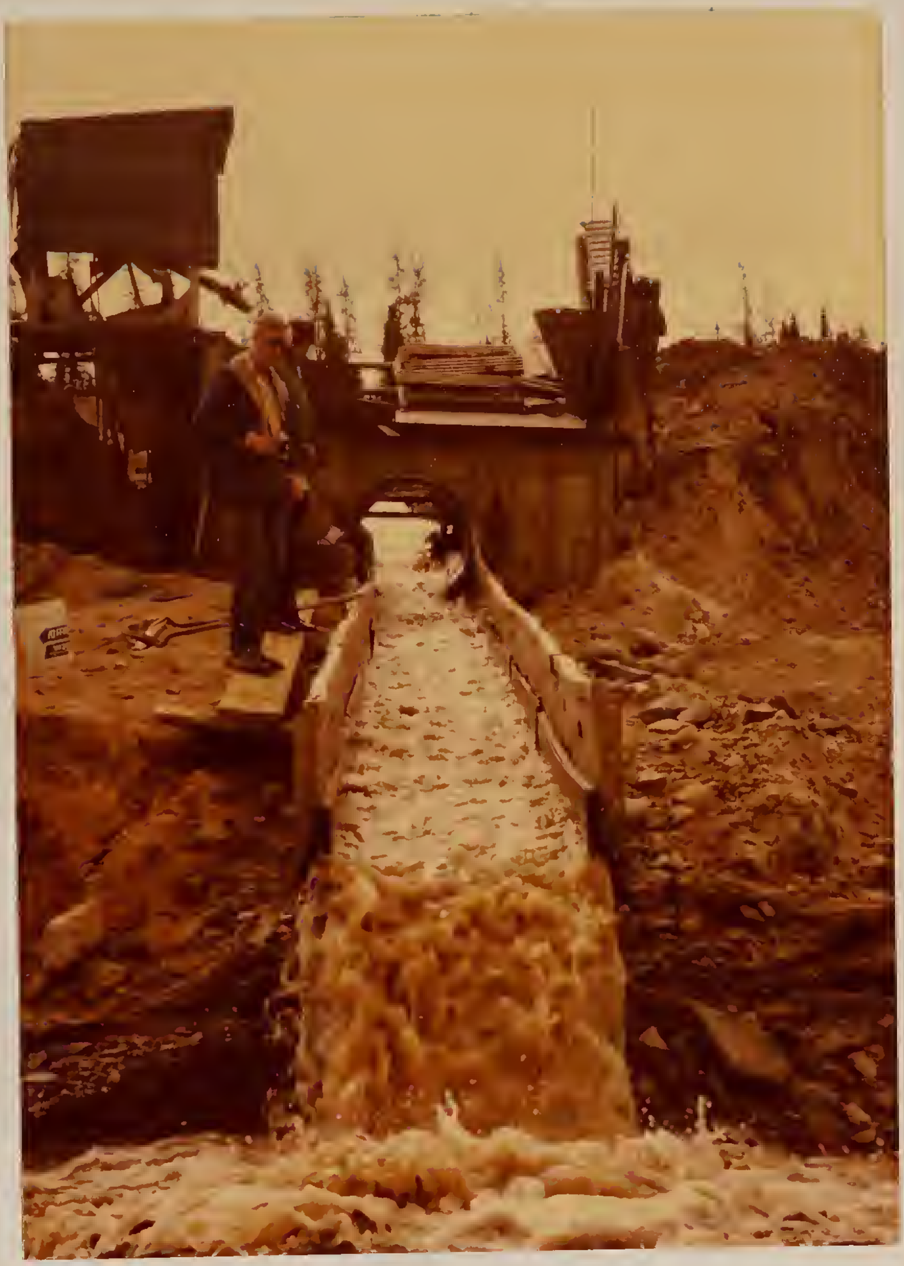

Figure 12

This operation, although not in routine operation during mid-July, was running a few hours per day. Thus it is not known what the visual effects would be on Otter Creek. Figures 13 and 14 illustrate the stream and streambed

conditions on Otter Creek, two miles below the site of active mining, late in the afternoon of a part-time mining day.

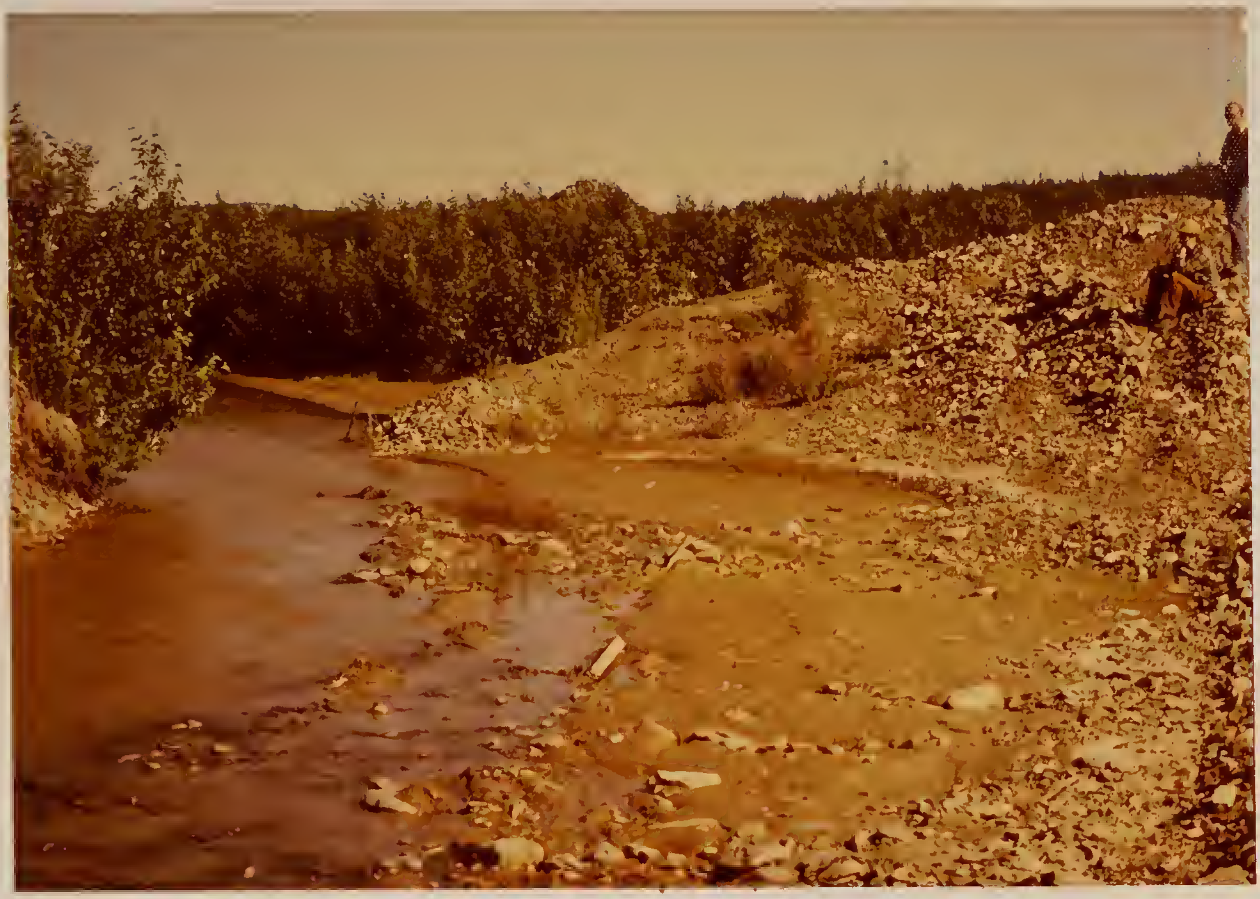

Figure 13.

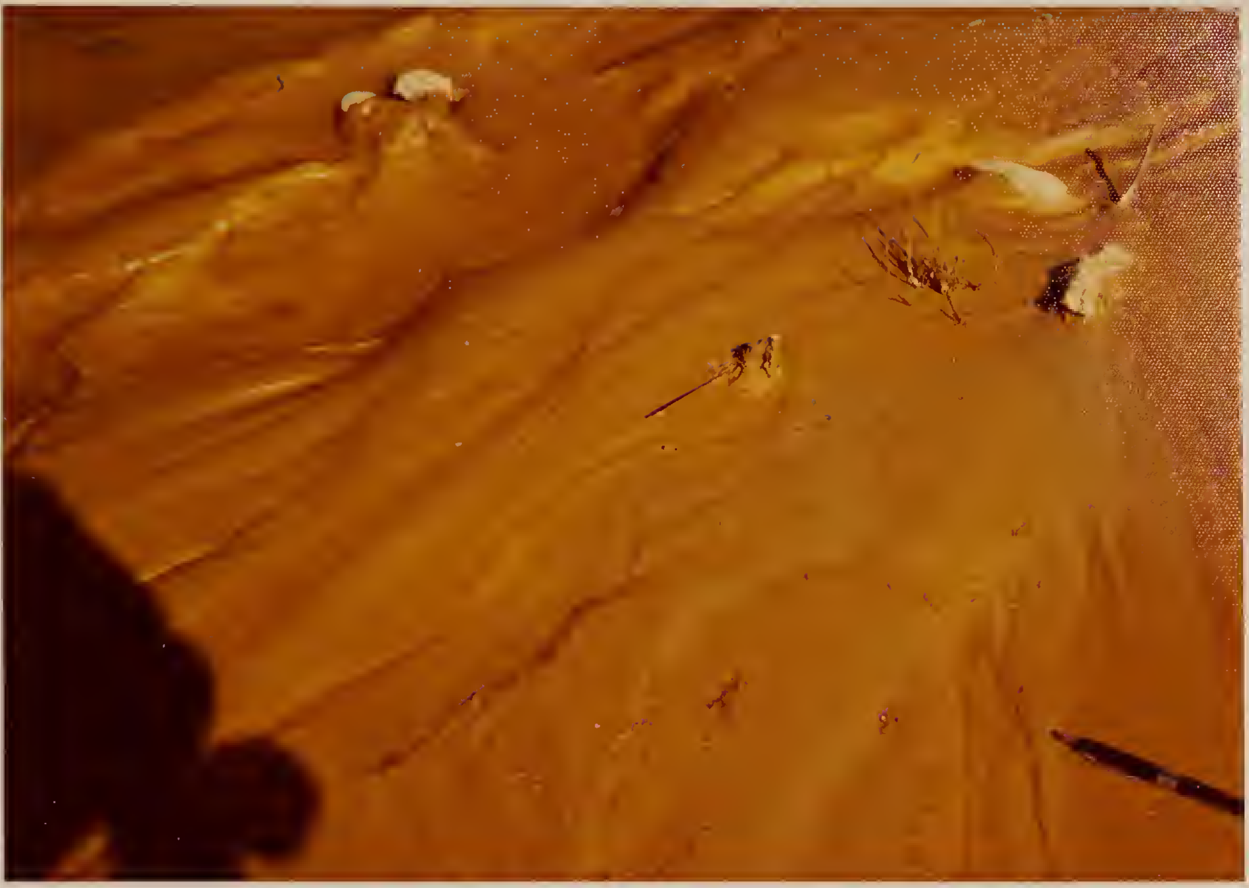

Figure 14.

Water at the location of Figure 13 and 14 appeared to exceed the State of Alaska 25 JTU threshold for aquatic life, the maximum incremental increase allowed at placer operations, although some three miles lower on Otter Creek (Figure 15), water turbidity appeared little affected on the morning of July 18, 1977.

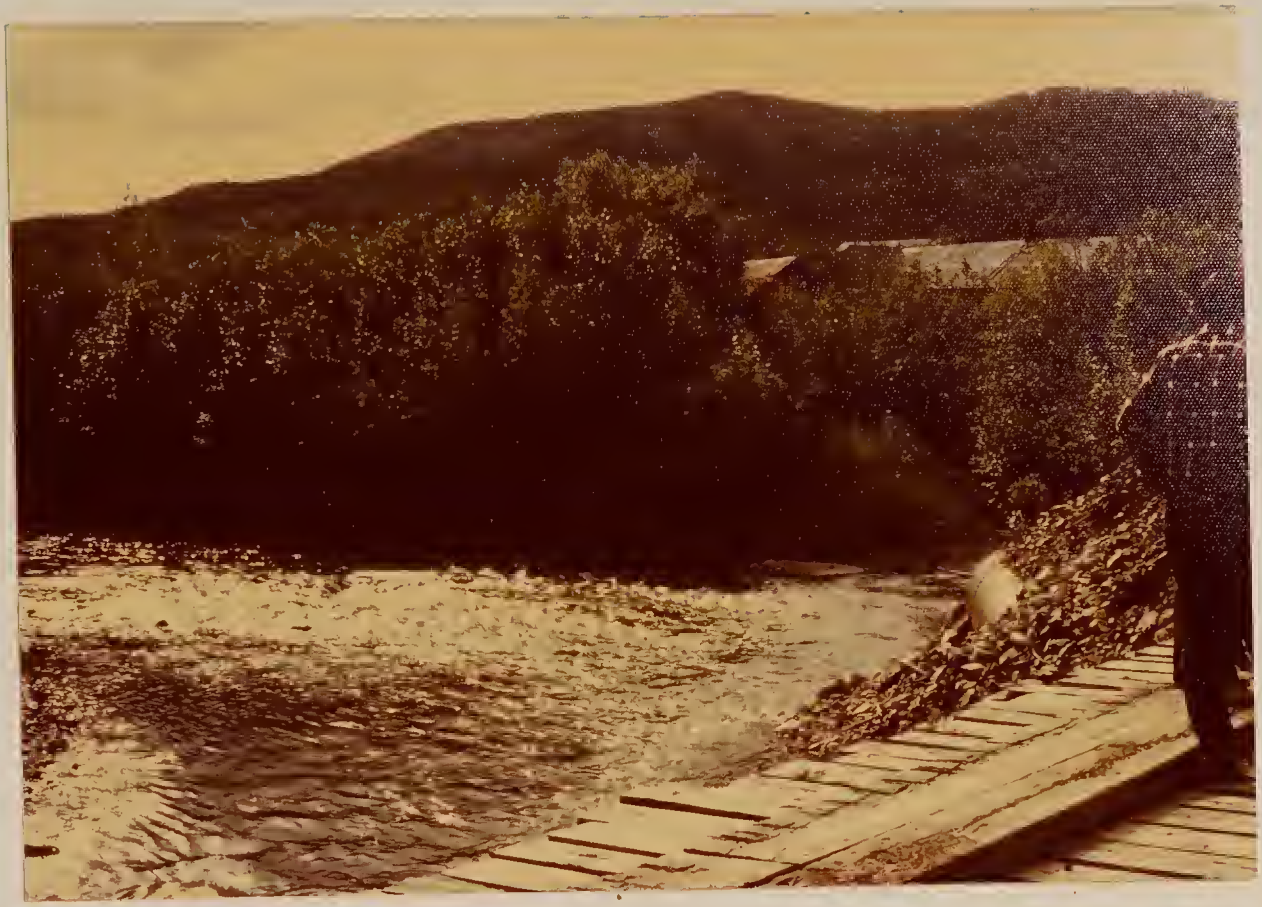

Figure 15.

Observations made during this visit indicate the mining effluent flows to Otter Creek via numerous small channels in older gravel tailings. It is to this natural system of filtration that the Alaska Water Laboratory (USDI, 1969) attributed the marked reduction in sedimentation and turbidity at the Slate Creek mine. That study found turbidities

as follows: mine water supply, 3.5 JTU; Otter Creek above confluence of Slate Creek, 5 JTU; Slate Creek immediately below the mine, 3600 JTU; and Otter Creek at Flat, 250 JTU (Figure 15). From these data it is apparent that Otter Creek dilutes greatly the mine effluent from Slate Creek; however, sampling now under a different mining schedule and for different constitutents would certainly give different results.

The Environmental Protection Agency has issued (Miscovich, 1977) an NPDES point discharge permit, with operating stipulations, to the Otter Creek Dredging Company. However, should that agency of the State of Alaska, begin enforcement of the turbidity (25 JTU) and settleable solids (0.2 milliliters per liter) permit conditions or dissolved oxygen water quality standards (Title 18, Alaska Administrative Code) high in the Iditarod drainage on Otter and Slate Creeks, mining operations could simply not comply. The farther down in the Iditarod one chooses

for a water quality benchmark point, the more diffuse becomes the significance of Slate Creek mining to water quality of the Iditarod River.

Given presently available data, it would be impossible to assess the significance of gold mining operations at Flat on the quality of the Iditarod or even the Yukon below the Innoko confluence since adequate records are not available. The great year-to-year variation exhibited by U.S. Geological Survey (1976) data for Kuskokwim River at Crooked Creek (Station No. 15304000) warn of even greater problems in defining the "natural" streamflow, turbidity, sediment and water chemistry relationships in higher watersheds like Otter and Slate Creeks, where the immediate and larger impacts of hydraulic mining are felt.

To summarize the water quality assessment of Slate Creek mining

operations, most of the potential damage to Otter Creek has already been done via the extensive dredge boat operations in the valley bottom. The Slate Creek mine is a small operation, employing but two men May through October. Mining effluent would seem manageable by utilizing filtration ponds and channels in the old workings downstream. In general, there is little or no treatment of stripping and sluicing mining effluents at Alaskan mining operations. The informal treatment of distribution through old tailings at Slate Creek is a system which may be practicable from the miner's standpoint and water quality effective from a biotic position. The Otter Creek Dredging Company operation thus provides a unique opportunity to monitor the effectiveness of such a waste treatment system.

E. Happy Creek

This three-yard dragline, elevated sluicebox and bulldozer operation employs two men on Happy Creek, an intermittent

tributary of Willow Creek (18 square-mile basin) and ultimately of the Yukon River (Figure 9). Since the operation requires 300 gallons per minute for six hours a day, water supply is a real problem and has forced the owners to install a recirculation system whereby water is pumped from a pond just below the sluicebox back up to the elevated intake at the head of the sluice. Situated five miles south of Flat at a considerably higher elevation, permafrost is more of a problem, as are bedrock springs (50 gallons per minute).

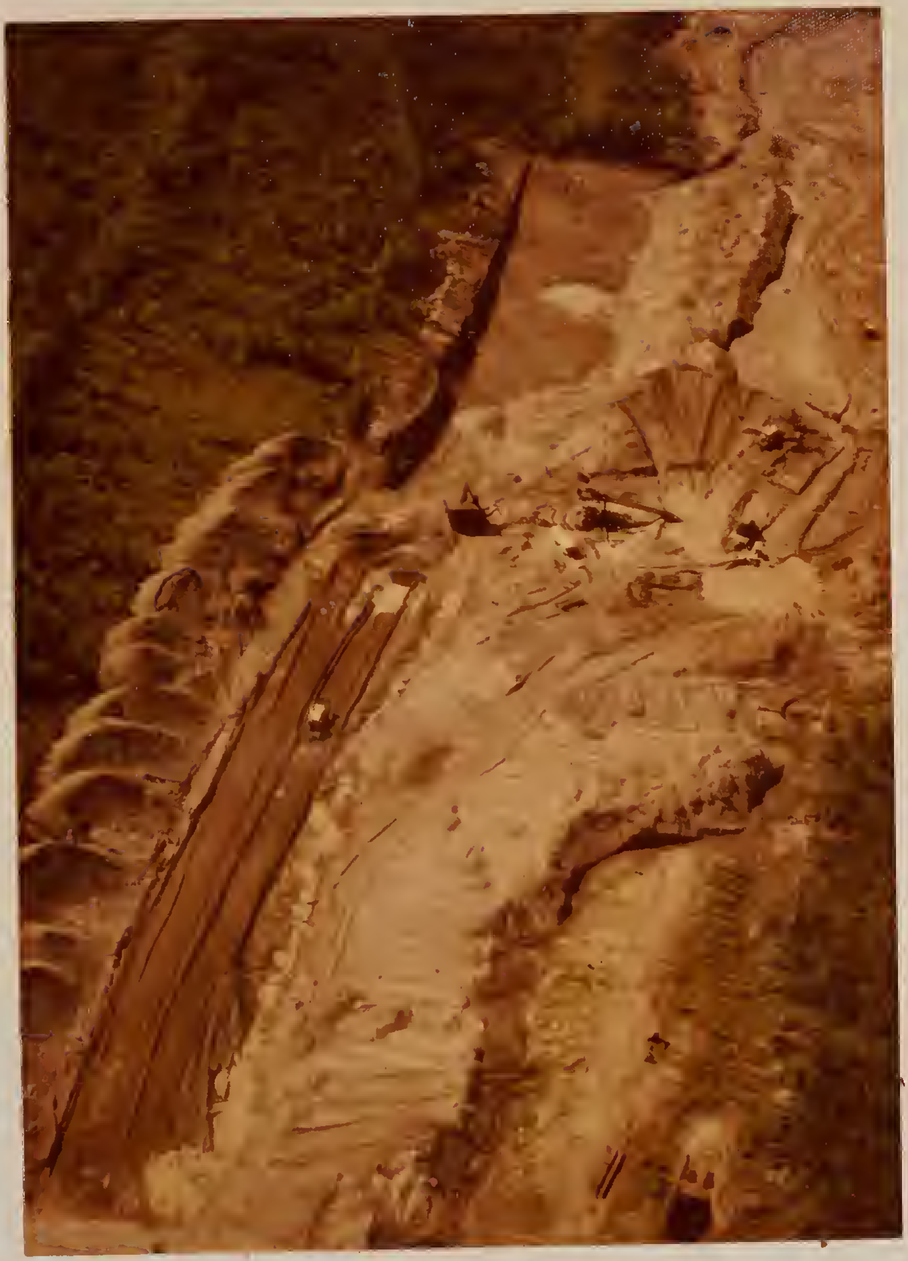

Figure 16.

July 18, 1977 aerial view of Happy Creek operation illustrates the large disturbance produced by less than one years' activity.

Gold-rich gravels are pushed downslope in the trench from the lower left up to where the dragline can reach the material and swing it around to the hydraulically washed sluicebox. The

gravel is washed down through the sluicebox, gold is trapped in the riffle bars, and sediment is bulldozed out of the settling basin (right center of Figure 17). Note the pump and hose used to recirculate the washwater back to the beginning. The next photograph shows the Happy Creek elevated sluicebox in greater detail (Figure 18).

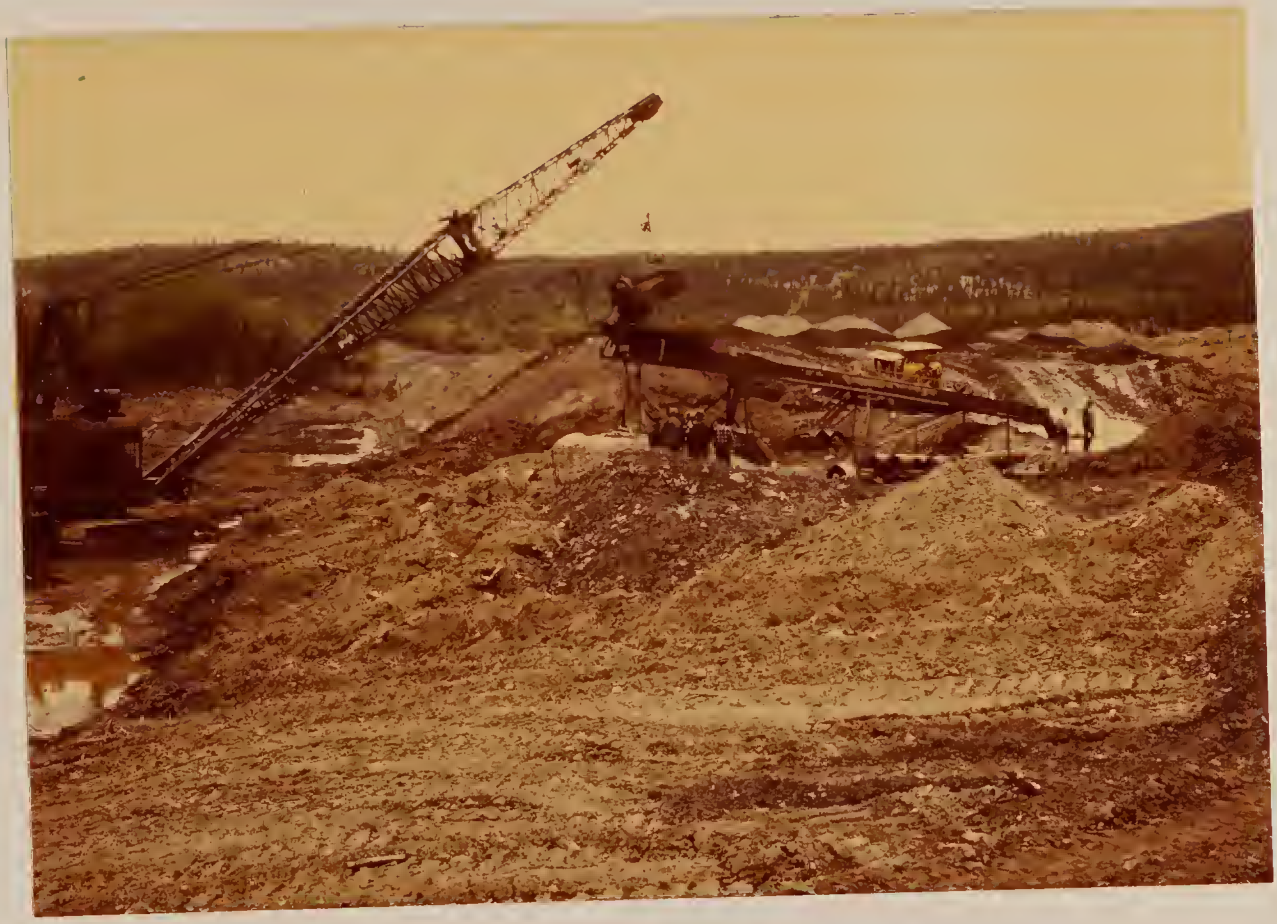

Figure 17.

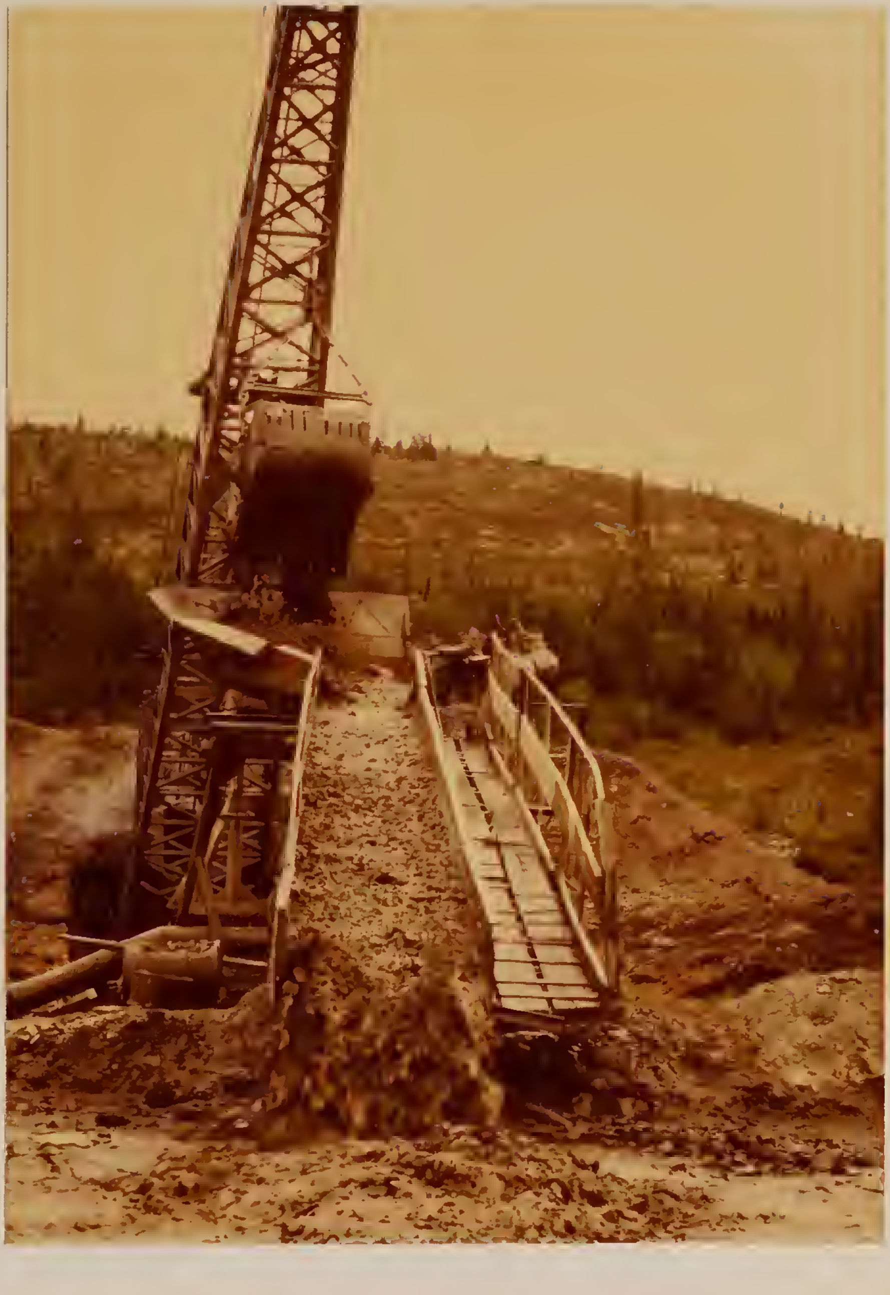

Figure 18.

Whereas the Slate Creek operation discussed previously required approximately 192,000 gallons of water per day, the Fullertons require only 108,000 gallons to move roughly the same yardage

(500 cy per day). The difference is, of course, due to the more efficient use of water on the "dry gulch" operation. Since the Happy Creek mine uses about 50 percent less water, most of it being recycled, it is tempting to conclude that the latter method has less of an adverse impact on the streamflow quality of Happy and Willow Creeks, but the reverse may be true if a comparison is made to the quality of gravel washwater effluent from operations in Alaska, California, and Colorado (Woodward-Clyde Consultants, 1976).

Table 2 presents a range of concentrations for selected parameters from sand and gravel washwater effluent.

Turbidity values of 200 to 300 JTU are common downstream from dredging and washwater discharge areas in Idaho and Colorado (Webb and Casey, 1961; FWPCA, 1968). Downstream from an Oregon dredging operation, values as high as 600 to 3000 JTU have been measured (Woodward-Clyde, 1976).

Table 2.

Sand and Gravel Washwater Effluent Quality
(Woodward-Clyde Consultants, 1976)

Parameter	Concentration Range
Biochemical oxygen demand (BOD_5)	3-30 mg/l
Chemical oxygen demand (COD)	10-2400 mg/l
Total dissolved solids (TDS)	200-10,000 mg/l
Turbidity	900-16,000 JTU
Total suspended solids (TSS)	3000-35,000 mg/l
Settleable solids	100-4000 ml/l
Alkalinity	150 mg/l
Kjeldahl nitrogen (approximately comparable to ammonia plus organic nitrogen)	1.5 mg/l
Nitrate nitorgen (NO_3)	15 mg/l
Hardness	200 mg/l
Chloride	50 mg/l

Even though relatively small quantities of effluent may be discharged into Happy Creek from the operation, the concentrating of dissolved solids, nutrients and other physical factors continues. This is because of increased dissolution of mineral matter due to the physical action of handling and sluicebox through-flow. Alkalinity, hardness, and chemical

oxygen demand all are very likely to be at higher levels than they would be if the water were used once and then discarded. August 1968 field measurements of the Alaska Water Laboratory (USDI, 1969) showed that turbidity of the water being pumped from the catch basin to the sluicebox had a value of 77,000 JTU, whereas the sluicebox effluent (Figure 18) was 10,000 JTU.

In comparing the relative water pollution effect of the Slate Creek and Happy Creek mines in this vicinity, we are handicapped with practically no information, but it appears that Happy Creek mine is more potentially damaging due primarily to the concentrated mineralization which the operation allows. The smaller discharges can thus carry large amounts of pollutants. There also appears to be a greater opportunity for impacts from the Fullerton's mine to be transmitted down to the Iditarod due to 1) steeper stream gradients and 2) shorter distances. Specific operating conditions, influent water quality, and the

materials being mined will exert a large control over the exact effects of a closed circulation system on water quality.

F. Tuluksak Dredging Ltd.

The only operation viewed on the ground in southwestern Alaska was the Tuluksak Dredging Ltd. of Nyac, Alaska. Dredge mining is a surface mining method which involves the removal of ore or gravel from underwater. It usually results in large numbers of water-filled pits, especially where the floating boats are being used. Suction dredging, other form of dredge operation, is not addressed in this paper.

Located on the headwaters of the Tuluksak River, within the Kuskokwim drainage system (Figure 3), the present company has operated one floating boat from the end of May through the end of October each mining season since 1962. This highly mineralized area 450 miles west of Anchorage experienced a

gold rush in 1910-13 with 2500-3000 people in the area. The number of employees at this particular Nyac operation (stands for the New York-Alaska Company, peaked at 150 in 1938 in support of four dredges, 15 years after the establishment of that earlier ownership.

Mr. Charles Awe, the current operator runs two 12-hour shifts per day, seven days a week through the season. A minimum of three men are required per shift. The Nyac dredge, unique in this part of Alaska, was built in Seattle in 1935. Electricity, generated by a small hydroelectric plant on the western edge of the company's 400 unpatented mining claims, runs the boat and also supplies the power needs of the base camp, except in winter when fuel oil provides energy needed for heating the quarters of the owners.

The dredge operation (Figure 19) includes a 64 bucket line

which digs at the rate of 24 buckets per minute. The digging ladder operates at a maximum depth of 26 feet below water level. Gravels arrive at the upper end of the trommel screen by bucket (Figure 20), are dumped inside the screen (Figure 21) which sorts the fines and gold from the coarser fragments. From the trommel, the gold and fine gravel go to one of three sluice line and flume setups (Figure 22). Fines are discharged continuously from the rear by one of two flumes (Figure 23). The coarser material is sorted once for gold and then conveyed up and out the stacker at the rear of the boat (Figure 24). Fine materials (less than 1/2 inch) are thus placed on the bottom of the tailings piles and overlain by coarser materials from the stacker. This fact, in concert with bedrock, is responsible for the tightness of many of the waste ponds, thus preventing deep percolation. Although the stacking boom does not pivot, the boat itself does, by pulling against one of two bulldozer anchors.

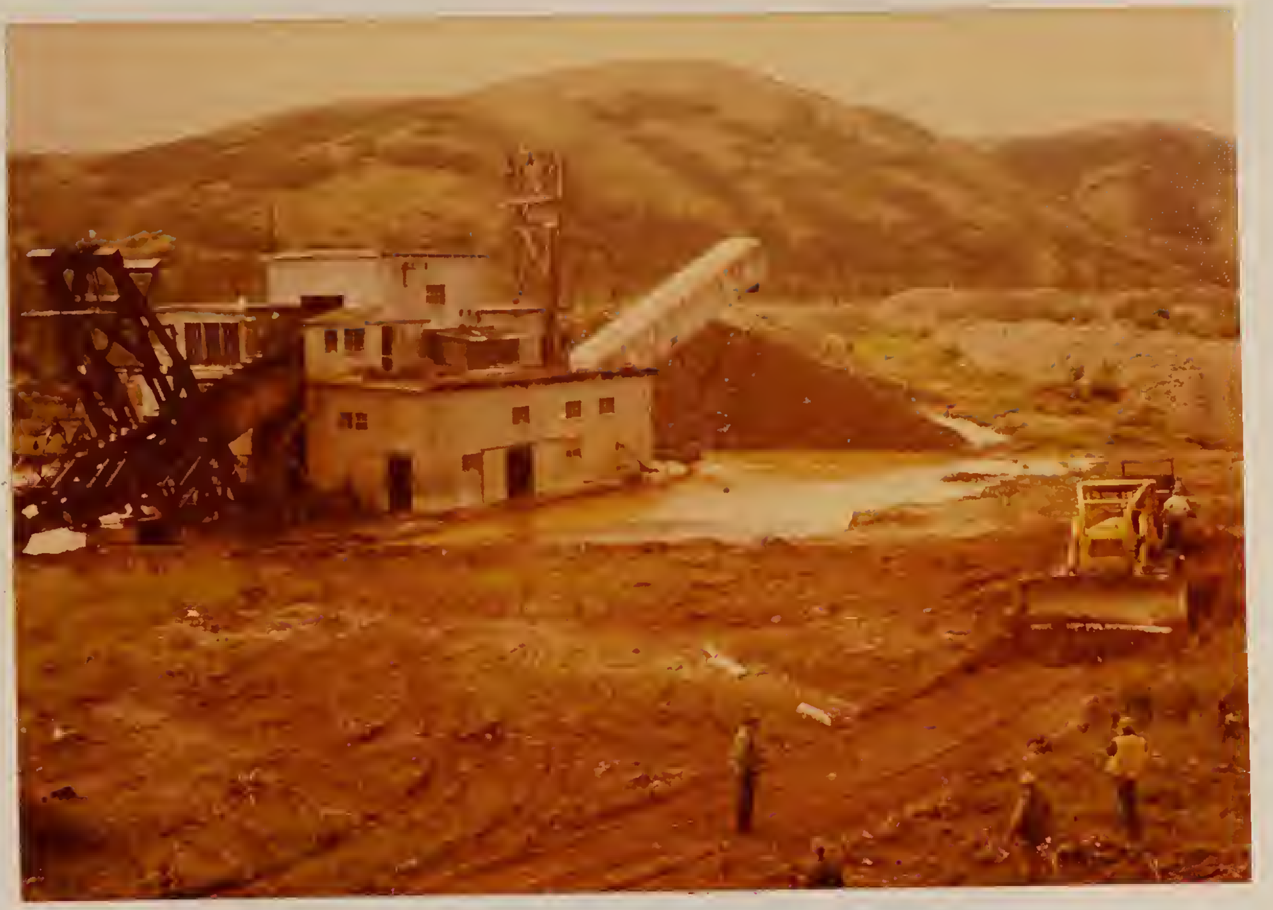

Figure 19.

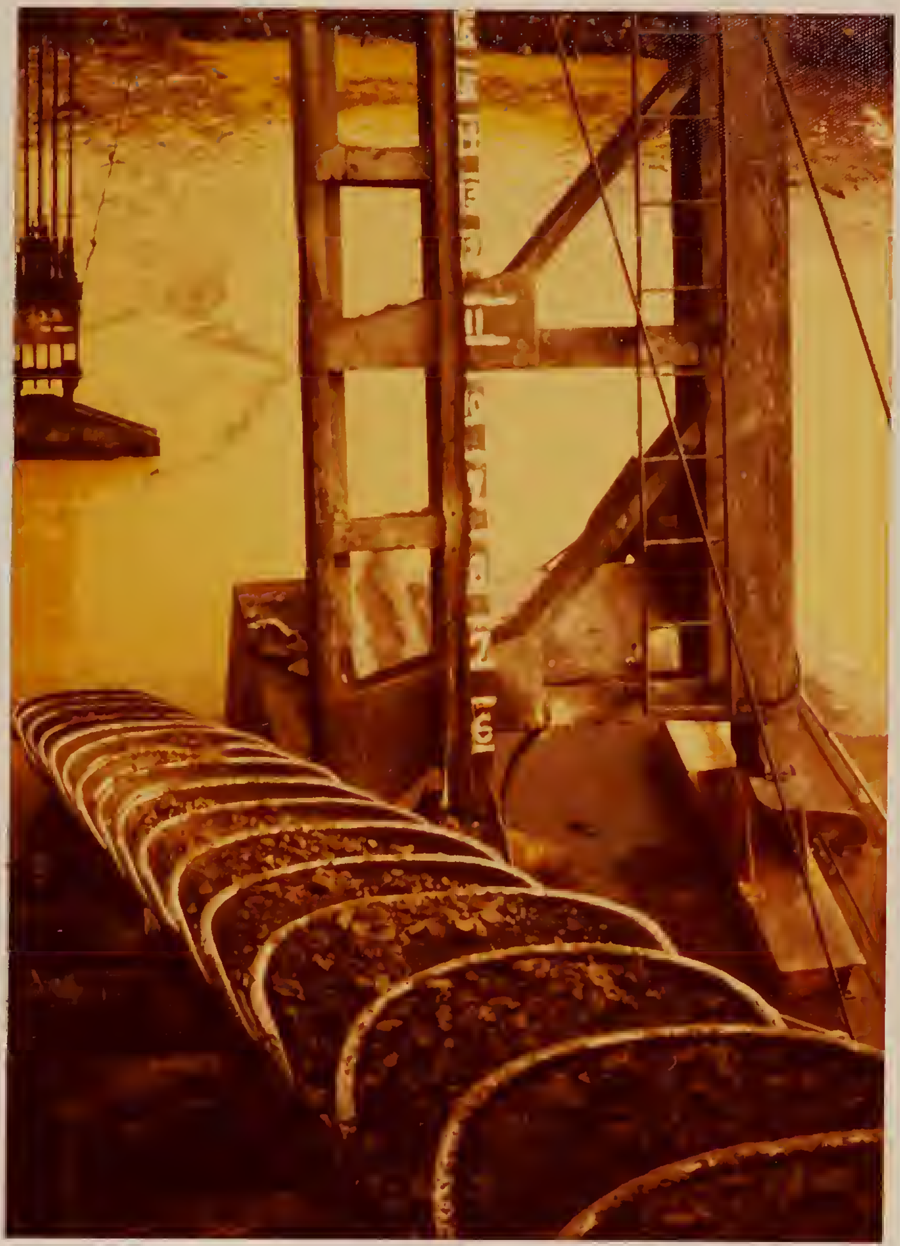

Figure 20.

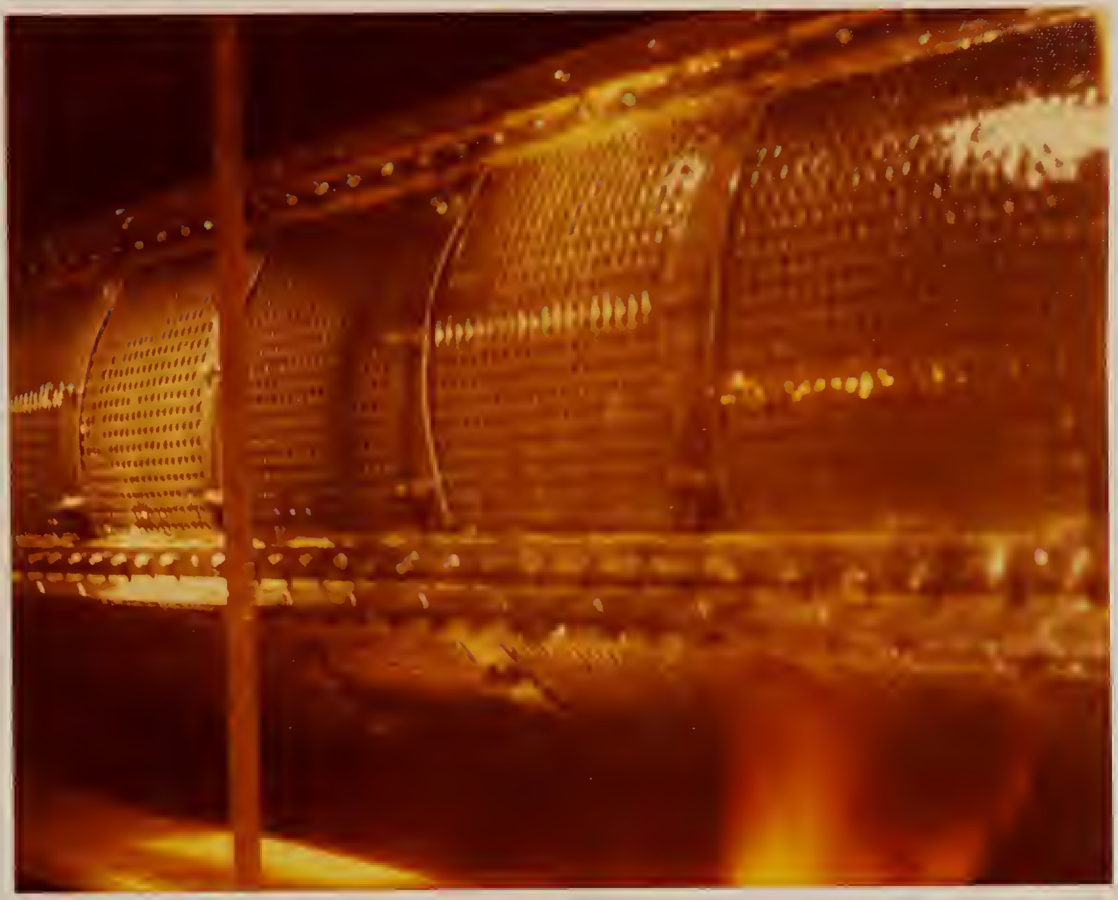

Figure 21.

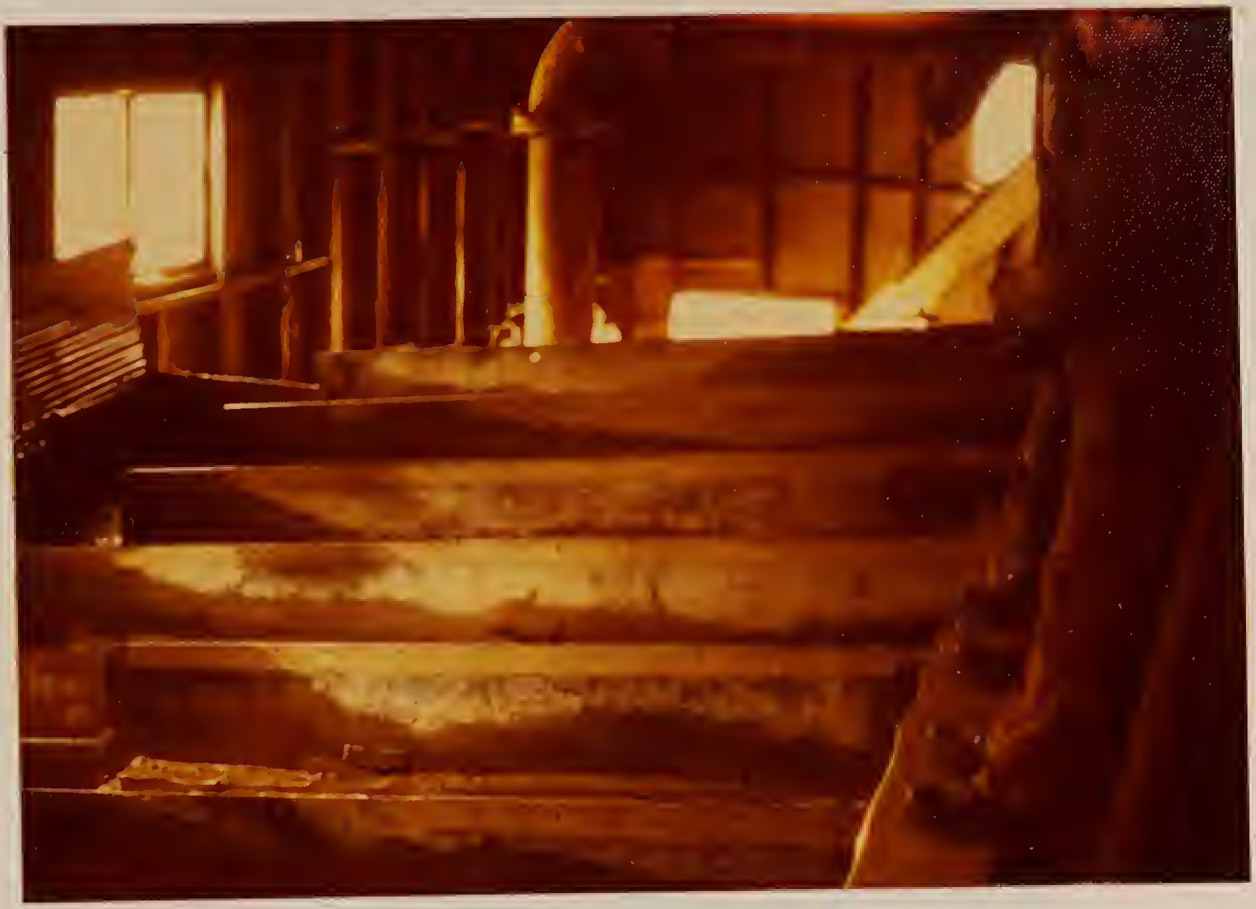

Figure 22.

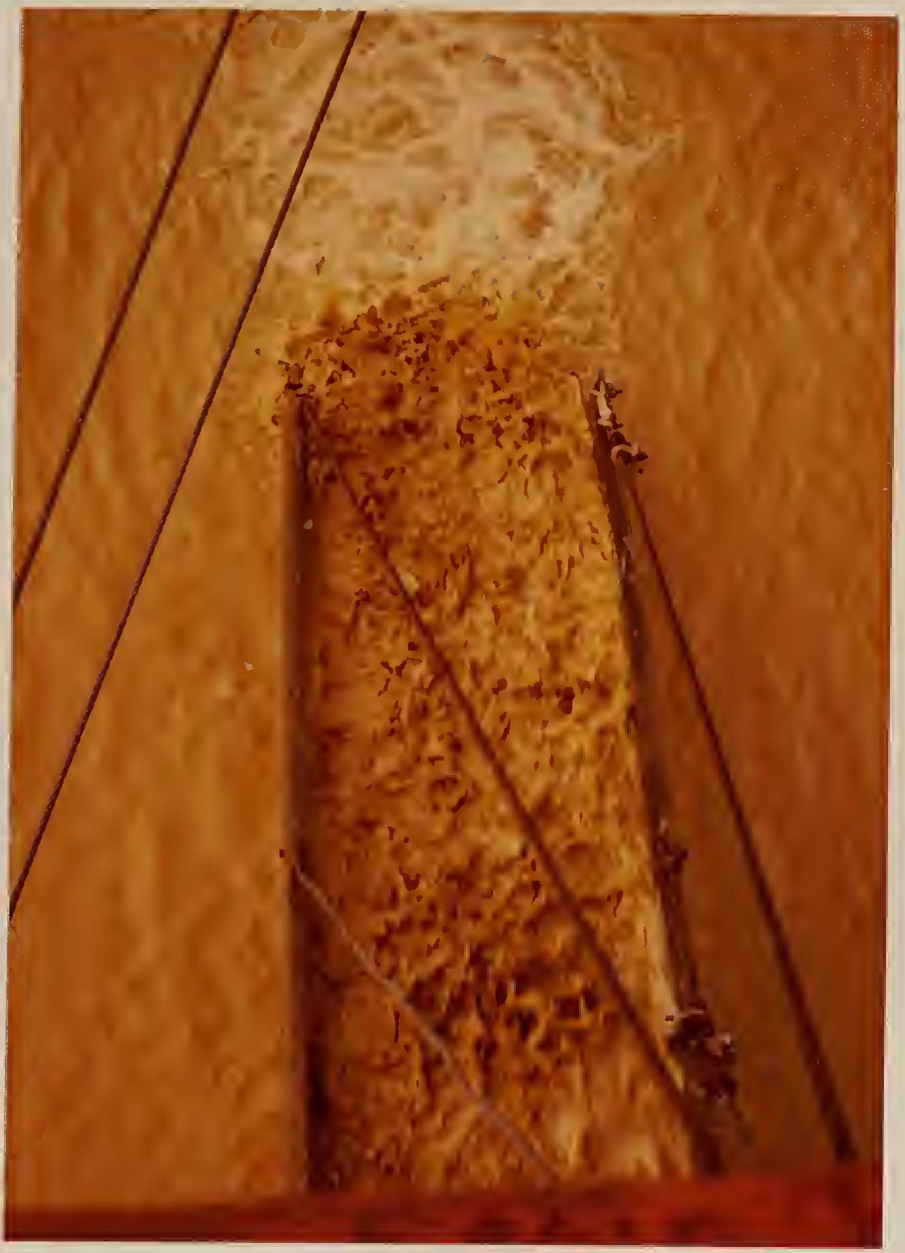

Figure 23.

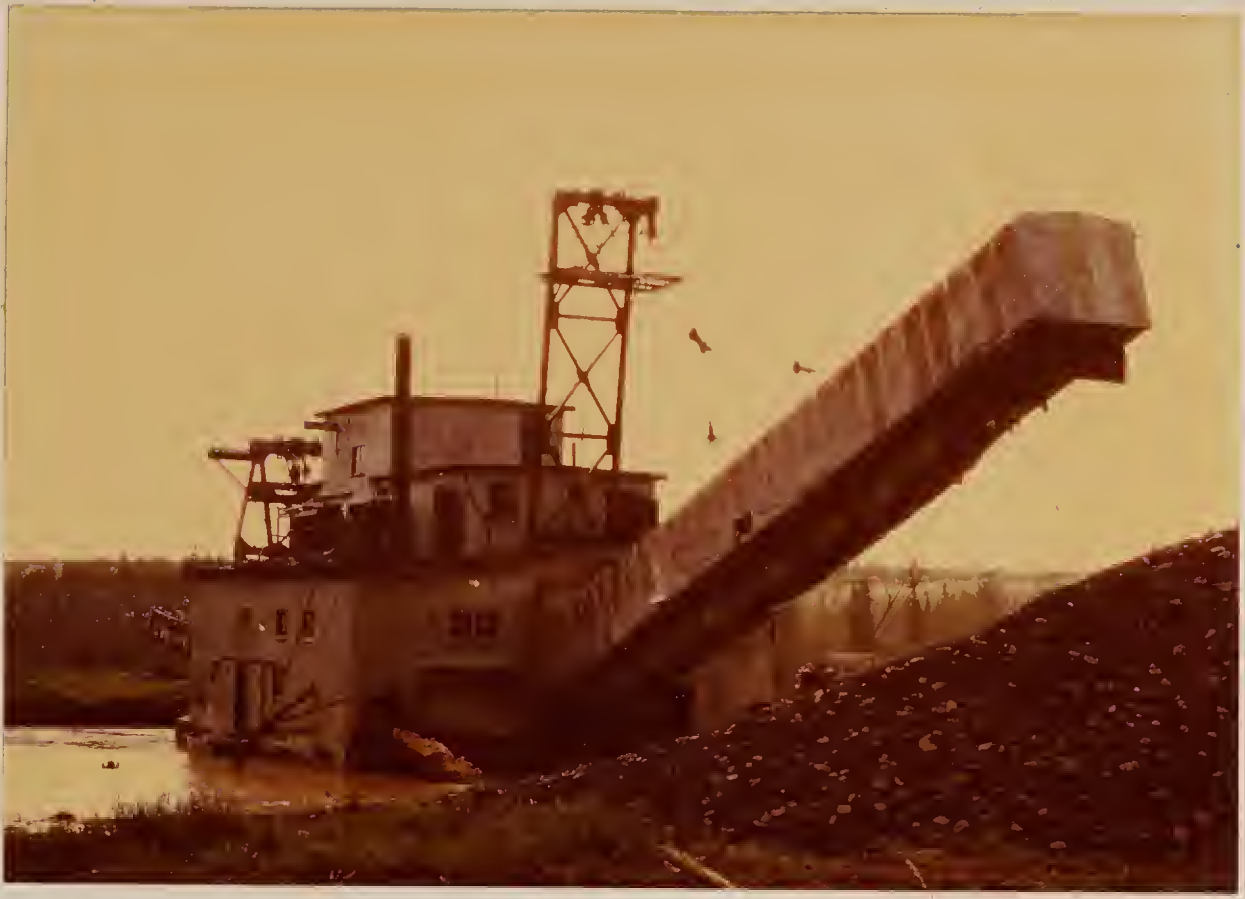

Figure 24.

Water is supplied from the channel of the Tuluksak River, in which the mining is taking place. It appears from field inspection that periodically during the summer the river is blocked by stacked tailings. The channel, floodplain

configuration, and physical location are completely changed by the mining as activity proceeds upstream. In the spring of 1976 the Environmental Protection Agency issued a National Pollutant Discharge Elimination System (NPDES) permit to the operator, with a maximum allowable turbidity increase of 25 JTU and a settleable solids limit of 0.2 ml/l. Monthly sampling by the operator is one of the permit stipulations. Tilsworth (1976) has found that although the dredge tailings at Nyac act as a filter, there still is sediment visible six miles downstream.

The argument is frequently heard that dredging these mountainous valley bottoms actually improves their productivity and diversity in terms of fish and wildlife potential and needs (Herbert, 1976). There is little evidence to prove or disprove this claim. The only water quality assessment learned of during this review which pertains to dredging operations is

one conducted in 1968 by the Alaska Water Laboratory in the Koyukuk mining district 250 miles northwest of Fairbanks (USDI, 1969). Conditions at the Hog Mine, where the earlier study was conducted, are too variable to justify extrapolation to any location in the Tuluksak watershed. Results of the USDI 1969 study are not definitive enough to be used to prove or disprove such a hypothesis.

Our review of Awe's Nyac operation points out several factors which should be kept in mind when comparing the disturbances of this type of mining to hydraulic stripping or simple sluicebox operations. *First*, it is likely that most stream, river and lake environments in Alaska which are feasible to mine with the floating dredge, uner current gold market prices, have already been developed. *Second*, the old remains of dredge mining suggest a potential for more *extensive* land disturbance and a higher relative impact on riparian zones, than that

associated with other gold mining methods. _Third_, present-day dredge mining operations in Alaska, which propose significant stream diversions and/or alteration, are closely regulated by the Alaska Department of Fish and Game under authority of the 1959 Anadromous Fish Act (A.S. 16.05.870). Other mining methods are subject to this Act only if their operations directly affect the channel.

Fourthly, dredge mining, because of the large scale changes it places upon the stream channels, may have more serious effects in the long run on river mechanics (aggradation, degradation, cutting patterns, channel shifting) than on quality of water. This might indirectly adversely affect water quality if suspended solids became more easily transported by a man-induced river mechanics change. Another example of a deleterious effect of these physical channel changes is that frequent shortening of the channel resulting from dredges can increase water

velocity, leaving less travel time for the water and thus natural assimilation of wastes and nutrients. Fifthly, there should be a fairly good relationship between the turbidity damages of dredging on a river and the presence of finer textured soil particles in the confining overburden. Sixth, it is generally acknowledged in this type of mining that recovery in water quality and biological population stability begins first below the area or operations and continues upstream toward the areas of more recent disturbance.

IV. DISCUSSION

It has been pointed out that many of Alaska's major rivers are naturally silt-laden for significant summer periods during which time the glaciers are melting. Annual spawning activities of various fish species have evolved with, and become adapted to, this highly turbid environment. There is no question, based upon this report and earlier work, that mining activities like sluicing,

stripping, and dredging discharge additional settleable and suspended solids to major river systems and the headwater streams. This man-made supplement of solids and possible chemical loading may or may not be adding to the river systems in a natural cyclic pattern.

Thus, the impacts of increasing turbidity, changes in annual cyclic pattern on fish migration and spawning, bottom siltation and scour, need assessment in relation to placer mining operations.

Besides the question of these artificial perturbations due to mining, there also is the siltation of some streams which might otherwise be clear.

At the Livengood mines, a problem with meeting State turbidity standards has been shown. Heflinger (1976), in reviewing Livengood mining operations, stated that settling ponds and

filtering were unable to lower values below 100 JTU. The Slate Creek mine above Flat appears to have a similar compliance problem even using the Otter Creek bridge at Flat as a checkpoint (USDI, 1969).

Despite the objections of the mining industry and some specialists in the water quality field (Pickering, 1976), the fact remains that measured suspended solids or turbidity downstream of a placer operation on a clear water stream constitute one of the best measures of mining impacts on water quality.

It is recognized, however, that there is much more to the characterization of water quality than these aesthetic factors; for example, nutrients, pH, heavy metals and biological toxicity. Our feeling is that on smaller streams, the hydraulic stripping method may result in serious biological oxygen demand increase because of organic matter carried into the stream by mining effluent.

Even though the effects of placer activities may be more difficult to detect in glacial or naturally turbid streams, does this necessarily imply that consequences of such mining are of less seriousness on this type of stream? In terms of turbidity and total suspended solids, the impact is probably semi-proportionately less with increasing natural turbidity. However, this conclusion is not valid when one considers other chemical and physical water quality parameters.

The EPA is the federal organization responsible for implementation of PL 92-500, the Federal Water Pollution Control Act Amendments of 1972. In accordance with Section 304(e) of the Act, the Administrator has issued, with regards to mining, "information including (1) guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollutants, and (2) processes, procedures, and methods to control pollution." However, this document (EPA, 1973) falls far short of any adequate treatment of

placer methods. It does not provide the degree of detail that would be needed for it to stand alone as a pollution control or abatement reference. Furthermore, most of the EPA report (1973) is based upon studies and pollution control measures conducted at coal operations in the Eastern U.S. Placer techniques barely receive any attention at all in the 1973 guidelines.

The EPA has been criticized by Alaskan environmental organizations and miner alike for taking no further actions since 1973 to put detailed placer mining effluent and control technology into the hands of the users. Given the small body of research available on water quality studies of placer mines, such additional technical guidelines may be impossible to write until far more studies are performed. Effluent guidelines and standards for mineral mining and processing point source category, (40 CFR 436; 40 FR 48652 and 48665 (1975)) and effluent guidelines for ore mining (40 CFR 440; 40 FR 51722 (1975)), have been published but were later suspended by EPA.

Public Law 92-500, Section 307, also requires that certain water quality standards for waste effluent be determined and published by EPA. As of early 1976 (Lamoreaux), standards as applied to placer mining in Alaska were still in the discussion stages; however, by early 1977 the decisions on these standards were finalized (Massi, 1977).

Turbidity standards for mining waste effluent in Alaska are specified as an NPDES permit condition of no more than 25 JTU increase above ambient turbidity. This is, strictly speaking, a State of Alaska Department of Environmental Conservation water quality standard (Alaska Administrative Code, Title 18, Chapter 70), which has been adopted by the EPA at state request. Settleable solids were set by EPA at the volumetric limit of 0.2 milliliters per liter (Imhoff cone technique). The EPA requires the operator to take samples once a month during mining season, with a compliance deadline of May 1, 1977.

Determination of the above effluent limitations has allowed EPA, beginning in 1977, to initiate processing of permits for placer miners under Section 402 of the Act (NPDES). Some 150-200 permits have been granted by the Agency since January of 1977 (Massi, 1977), with many of these going to protest hearings this October. A common cause of protests is the alleged impossibility of compliance with the turbidity standard and the 0.2 m/l settleable solids effluent limitation. The Alaska Operations Office of EPA, recognizing local resistance to sampling with an Imhoff cone, did allow an alternative NPDES permit condition. That was the construction and use of a settling pond of sufficient capacity to detain 24 hours of effluent discharge. Since terrain limitations generally make construction of large settling ponds infeasible at most operations, many miners are forced to do Imhoff cone sampling once a month to demonstrate compliance with EPA's settleable solids effluent limitation; this is a basic issue for the October 1977 protest hearings in Anchorage. Although the State of Alaska did not assume responsibility for

NPDES permits in Alaska, active involvement is provided for through draft permit review and State certification of the discharger's compliance with PL 92-500.

It appears that there are some friction points between the water quality goals and pursuant regulations of the Federal Water Pollution Control Act, and the 1872 Mining Law. The earlier legislation gave the independent miner a right to exploit a locatable mineral claim with very little regard to preservation of any other on-site environmental values. Many years later (1972), Congress asserted its objective of "restoring and maintaing the chemical, physical, and biological integrity of the Nation's waters" with passage of PL 92-500.

In the five years since PL 92-500 was enacted, a period of reckoning has passed as regards the dealing with placer mining. Effluent standards are now defined for Alaska. The NPDES permit program is

operational, even though many petitions of protest are currently under consideration.

Proposed regulations, published December 6, 1976 by the BLM, concerning surface management of mining claims on federal lands contain two references to water quality which should reduce some of the friction between PL 92-500 and miner's rights. The first is that within Section 3809.0-5, the term "significant disturbance" implies that water degradation to a degree which violates Federal or State water quality standards constitutes "significant disturbance". Secondly, Section 3809.3-2 states that "the operator shall comply with applicable Federal and State water quality standards, including regulations issued pursuant to the Federal Water Pollution Control Act Amendments of 1972."

Several miners mentioned to the authors during the field review that while the goals of PL 92-500 and regulations pursuant thereto

may be enforceable, they are impractical and unattainable unless the federal and state agencies wish to completely halt placer mining operations in Alaska. We are more optimistic. The on-going revision of the proposed BLM surface management regulations, the protest hearings scheduled for October 1977 in Anchorage, and the continuing opportunities for dialogue and cooperative study between officials of the Alaska Miners Association, BLM, USGS and the Alaska Department of Environmental Conservation, lead us to believe that regulations and standards can be modified which will allow placer operations to continue under reasonable water quality stipulations.

V. CONCLUSIONS

Specific placer mining operations in Alaska are very unique because of the great variability in climate, water conditions, gravel deposits, stream and land slope, vegetative-soil conditions and mining technology. Water quality compliance must be considered in relation to a specific operation. Because each mine has different

characteristics and problems, it is unwise to relate a universal water quality standard or effect across the diversity of mine operations. Realizing this, it follows that a large systematic water data station network is not the most productive philosophy for providing the needed hydrologic data. In view of severe logistical problems in Alaska, and variation between mining situations where water quality and climatological data collection are essential, they should be done on a specific project basis. After more knowledge is available concerning the effect of placer mining, and if rapid technological advances are made in instrumentation function and maintenance, the possibility of eventually expanding data collection efforts into a limited systematic hydrologic network may be more feasible.

It is very important that BLM begin soon with a modest data collection effort on the water quality, aquatic ecology, and hydrologic effects of one or more placer mining techniques for the

following reasons. First, good information is simply not available. Second, the timing in terms of PL 92-500 maturation, state concern, environmental awareness, and increasingly effective Bureau jurisdiction via PL 94-579 (Organic Act) is right. Third, many placer miners are thoroughly disgusted with the lack of agency followup to various water quality regulations and requirements.

It is therefore imperative that good scientifically credible, management information be obtained regarding the real effects of certain placer mining techniques on aquatic resources and water quality. Sincere attempts and unwise actions by operators to mitigate environmental damage associated with mining deserve careful feedback from the Bureau of Land Management, as the primary surface management agency. Lack of action by BLM on initiating appropriate studies will cast doubt in the future on the intent and worth of our manager's advice to the placer mining industry.

A study is proposed for BLM funding, to be done cooperatively with Water Resources Division, USGS. The primary objective is to quantify the effects of hydraulic placer mining on the water quality, flow regime, and aquatic biota of several mined Alaskan streams. The work will be funded for fiscal year 1978, under authority of the BLM/USGS EMRIA Work Order of August 15, 1974. This non-negotiated procurement will be obligated through a purchase order by the Branch of Procurement, Denver Service Center, during November of 1977. Monthly sampling will concentrate on the establishment of a baseline above and below two mining sites. Because water discharge is strongly influenced by basin area, and due to the importance of flow in mass transport determination, measurements of suspended sediment, turbidity, and other water quality parameters will be strongly tied to streamflow measurements.

It would be more desirable to evaluate effects of placer mining on water quality under more ridigly controlled conditions; for example,

at the Caribou-Poker Creeks experimental basins near Fairbanks. However, opportunities to evaluate gold mining operations are most dependent upon the presence of working mining claims, and therefore there is not the latitude in study site selection as might be desirable from an experimental design viewpoint.

One of the products expected from the USGS study is the establishment of criteria and standards for water quality assessments within mining plans. As Bureau manual instructions are non-specific in this area, the minimum acceptable field data and statistical reliability need specification.

Existing unpatented mining claims established under the 1872 Mining Law comprise 99 percent of Alaskan claims (Meyer, 1977). As such, Bureau jurisdiction of surface management relative to water quality is broader than for patented claims. Language of the Organic Act and subsequent proposed regulations of December 6, 1976 would

provide the BLM with a more clearcut role on unpatented mining claims. Requiring modifications for water quality enhancement to proposed operating procedures within a mining plan would be a role of the Bureau under the above proposed surface management regulations.

The present on-going statewide Section 208 water quality management activities, relative to placer mining and sediment production, are obviously important to the Bureau in Alaska. Under contract to the Alaska Department of Environmental Conservation, Engineering Manpower Services of Juneau will be completing its problem definition phase of the "208 plan" by October 31, 1977 (Worley, 1977). The 208 plan, named after Section 208 of PL 92-500 will describe Alaska's water quality situation as regards placer operations and possible control measures and special studies. The plan will give special attention to implementation strategies, and should focus much attention on this use of Alaska's public domain.

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APPENDIX A

WATER QUALITY CRITERIA FOR WATERS OF THE STATE OF ALASKA

18 AAC 70, October, 1973

Water Quality Parameters / Water Uses	(1) Dissolved oxygen mg/l or % saturation	(2) pH*	(3) Turbidity, measured in Jackson Turbidity Units (JTU)	(4) Dissolved inorganic substances	(5) Settleable solids suspended solids (includes sediment & dredge spoil & fill)	(6) Color as measured in color units
A. Water supply, drinking, culinary and food processing without the need for treatment other than simple disinfection and simple removal of naturally present impurities.	Greater than 75% saturation of 5 mg/l.	Between 6.5 and 8.5	Less than 5 JTU	Total dissolved solids from all sources may not exceed 500 mg/l.	Below normally detectable amounts	True color less than 15 color units.
B. Water supply, drinking, culinary and food processing with the need for treatment equal to coagulation, sedimentation, filtration, disinfection and any other treatment processes necessary to remove naturally present impurities.	Greater than 60% saturation of 5 mg/l.	Between 6.5 and 8.5	Less than 5 JTU above natural conditions.	Numerical value is inapplicable.	No imposed loads that will interfere with established levels of water supply treatment.	Same as above.
C. Water Contact Recreation	Greater than 5 mg/l.	Between 6.5 and 8.5	Below 25 JTU except when natural conditions exceed this figure effluents may not increase the turbidity.	Numerical value is inapplicable.	No visible concentrations of sediment.	Secchi disc visible at minimum depth of 1 meter.
D. Growth and propagation of fish and other aquatic life, including waterfowl and furbearers.	Greater than 6 mg/l in salt water and greater than 7 mg/l in fresh water.	Between 7.5 and 8.5 for salt water. Between 6.5 and 8.5 for fresh water.	Less than 25 JTU when attributable to solids which result from other than natural origin.	Within ranges to avoid chronic toxicity or significant ecological change.	No deposition which adversely affects fish and other aquatic life reproduction and habitat.	Same as A-6.

* Induced variation of pH conditions naturally outside this range may not exceed 0.5 pH unit and the pH change shall be only in the direction of this range. pH conditions naturally within this range shall be maintained within 0.5 pH unit of the natural pH.

APPENDIX B

Water Quality Related Authorities, BLM, Alaska

1. FEDERAL LAWS

Public Law 89-234. Water Quality Act of 1965.

Public Law 91-190. National Environmental Policy Act of 1969.

Public Law 92-500. Federal Water Pollution Control Act. Amendments of 1972.

Public Law 92-583. Coastal Zone Management Act of 1972.

Public Law 93-523. Safe Drinking Water Act of 1974.

Public Law 94-580. Resource Conservation and Recovery Act of 1976.

Public Law 94-579. Federal Land Policy and Management Act of 1976.

2. PRESIDENTIAL EXECUTIVE ORDERS

Executive Order 11514. Protection and enhancement of environmental quality. March 5, 1970.

Executive Order 11752. Prevention, control and abatement of environmental pollution at Federal facilities. December 17, 1973.

Executive Order 11988. Floodplain management. May 25, 1977.

3. STATE OF ALASKA LAWS AND CODES

Anadromous Fish Act of 1959. (AAC 16.05.870 as amended in 1960, 1962 and 1966).

Title 18, Alaska Administrative Code, Chapter 70, Water Quality Standards.

4. INTERAGENCY COOPERATIVE AGREEMENTS

Cooperative agreement between Environmental Protection Agency and Bureau of Land Management on coordination of planning conducted under Section 208, P.L. 92-500. January 5, 1976.

5. CIRCULARS, OFFICE OF MANAGEMENT AND BUDGET

OMB Circular A-67 on Water data coordination, August 28, 1964.

OMB Circular A-106 on Reporting requirements in connection with the prevention, control, and abatement of environmental pollution at existing federal facilities, December 31, 1974.

6. DRINKING WATER STANDARDS

Primary Drinking Water Standards, December 24, 1975 Federal Register. Finalized June 24, 1977.

7. GUIDELINES

Guidelines establishing test procedures for analysis of pollutants,

October 16, 1973 Federal Register 38(199): 28758.

Water Quality Manual, 7240 (Draft), Bureau of Land Management.

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